

Fuelwood and Vegetation Change in
Northern Nigeria: An Exploration Using
Remote Sensing (RS), Geographical
Information Systems (GIS) and Field
Reports.

Ali Ibrahim Naibbi

A thesis submitted in partial fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy of the University of
Portsmouth, UK.

June 2013

ABSTRACT

Forest is one of the natural resources that are facing a serious threat in the world today. Overexploitation of forest resources for timber, fuelwood and agricultural land is increasing faster, to the extent that the future prospects for most forest in the world are open to question. While there are various reasons responsible for the decline in vegetation, this study explores the situation of the Northern Nigerian region arid zone forest by studying the changing pattern of vegetation in relation to the cooking fuel situation in the region using both national and regional statistics and a local area case study. The study uses multiple methodologies (Remote Sensing, Geographical Information Systems and a local survey using household survey, focus group discussion and participant observation) to examine various aspects of the overall problem at different geographical scales. The combined methods serve as a triangulation strategy to identify causal linkages between changes in forest cover, fuelwood consumption and cooking fuel supply problems in the region. Past studies have used some of the methodologies, singly or in combination. However, no previous study has utilised the full range of methodologies listed above to examine the fuelwood problem across all scales from the national to local level, which is a contribution to knowledge that this present study offers.

The study commences by using a time series analysis of Landsat satellite images of the North-Eastern part of Nigeria (NEN), covering a period of about three decades, using the technique of Remote Sensing (RGB-NDVI model), with a view to identifying areas where deforestation is evident in the vegetated areas of the region. The results indicate that the vegetation of the area has drastically reduced since 1970s. However, both the pattern and causes of the observed change were non-linear. Similarly, evidence from ground truthing investigation has shown that fuelwood collection is among the major factors of deforestation in the region, mainly due to lack of alternative energy sources in the region.

This initiated a wider national exploration of fossil fuel supply and consumption in the country, with a view to examining whether there are any spatial patterns of such inequalities amongst households across the 36 states of Nigeria (and Abuja the capital city). Spatial analysis of the distribution and consumption of cooking fuel is conducted using Geographical Information Systems (GIS). The results show that fossil fuel supply is precarious in the country. The majority of the northern states are deprived of sufficient fossil fuel supply, and this is closely correlated with their dependence on traditional fuels (fuelwood), leading to considerable pressure on the region's scarce vegetation resources.

Further investigation of the national findings relating to fossil fuel supply is undertaken using a local survey, which explores the pattern of household fuel consumption and commercial fuelwood activities in some selected areas of North-Eastern Nigeria. The results also reveal that there are some local inequalities in the choice of cooking fuel among households (in favour of fuelwood), which is related to the unreliability in the supply of fossil fuel in the region (cooking fuel poverty). This has paved the way for the expansion of organised commercial fuelwood vending in the region to supply households with fuelwood.

DECLARATION

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

TABLE OF CONTENTS

ABSTRACT.....	II
DECLARATION	IV
LIST OF TABLES	X
LIST OF FIGURES	XII
LIST OF BOXES	XIV
LIST OF PLATES	XV
LIST OF ABBREVIATIONS.....	XVI
ACKNOWLEDGEMENTS	XIX
CHAPTER 1: INTRODUCTION.....	1
1.1. AIMS AND OBJECTIVES.....	3
1.1.2. Research Questions.....	4
1.2. NIGERIAN VEGETATION ZONES.....	4
1.3. BACKGROUND TO THE CASE STUDY	6
1.4. CASE STUDY AREA	7
1.4.1 History, Population and Ethnicity of the study area	9
1.4.2 Cultural background and Religion.....	10
1.4.3 Economy and Trade	10
1.4.4 Cooking Fuel Energy.....	11
1.5. BACKGROUND TO SOCIO-ECONOMIC DEVELOPMENT IN NIGERIA.....	12
1.6. POLICY ORIENTATION OF THE STUDY	14
1.7. STRUCTURE OF THE THESIS	16
CHAPTER 2: LITERATURE REVIEW	20
2.1. INTRODUCTION.....	20
2.1.1. Vegetation	21
2.2. OVERVIEW OF FORESTRY SYSTEM IN NIGERIA	24
2.2.1. History of Forest Management in Nigeria.....	24
2.2.1.1. The Present System of Forestry Administration in Nigeria	25
2.2.2. Vegetation Change.....	27
2.2.2.1. Deforestation.....	29
2.3. FUELWOOD.....	31
2.3.1. The Shortage of Fuelwood	32
2.3.2. Fuelwood Consumption	33
2.3.3. Fuelwood Demand	35
2.3.4. Fuelwood Procurement.....	35
2.3.5. Labour and Tools use.....	37
2.4. THE ROLE OF FUELWOOD COMMERCIALISATION ON THE SOCIO-ECONOMIC ACTIVITIES OF THE PEOPLE.	38
2.4.1. Seasonal Variation and Prices of Fuelwood.....	40
2.5. FUELWOOD VERSUS OTHER ENERGY TYPES IN NIGERIA.....	41
2.5.1. Fossil Fuel (Petroleum Products).....	43
2.5.1.1. Kerosene	46
2.5.1.2. Gas	48
2.5.1.3. Distribution of Petroleum Products in Nigeria	49
2.5.2. Electricity	51
2.5.3. Overview of Energy Subsidies in Nigeria.....	53
2.5.4. Transition from Fuelwood to Fossil Fuel.....	56
2.6. REMOTE SENSING (RS) STUDIES OF VEGETATION CHANGE.....	58
2.7. CHAPTER SUMMARY	59

CHAPTER 3: METHODOLOGY (REMOTE SENSING BASED STUDY)	62
3.1. INTRODUCTION.....	62
3.2. REMOTE SENSING (RS) APPLICATION	62
3.2.1. Data Sources.....	63
3.2.2. Choice of Remote Sensing (RS) Sensors	63
3.2.3. Image Processing and Image Enhancement	68
3.2.4. Normalized Difference Vegetation Index (NDVI).....	69
3.2.5. Satellite Image Classification.....	70
3.2.5.1. Supervised Classification	70
3.2.5.2. Unsupervised Classification and Image Masking	72
3.2.6. RGB-NDVI Classification.....	72
3.2.7. Remote Sensing (RS) Image Results Validation (Field Investigation).....	74
CHAPTER 4: VEGETATION CHANGE STUDY USING REMOTE SENSING (RS)	76
4.1. INTRODUCTION.....	76
4.1.1. Vegetation Change Patterns.....	76
4.1.2. Accuracy Assessment.....	83
4.1.3. Percentage of Vegetation Area Changed	87
4.1.4. Mapping the Development of Vegetation Change Patterns	89
4.2. DISCUSSION OF RESULTS	95
4.2.1. Population Factor.....	96
4.2.2. Rainfall Factor	98
4.2.3. Political Factors (Policies Regarding Afforestation and Agricultural Programmes).....	100
4.2.4 Deforestation and Agriculture	104
4.2.5. Deforestation and Fuelwood Collection.....	105
4.3. CHAPTER SUMMARY, CRITIQUE AND CONCLUSION.....	107
4.3.1. Chapter Summary.....	107
4.3.2. Chapter Critique	107
4.3.3. Conclusion	108
CHAPTER 5: METHODOLOGY (STATISTICAL ANALYSIS OF AGGREGATE SECONDARY DATA: FUELWOOD VERSUS THE OTHER COOKING FUEL TYPES IN NIGERIA).	109
5.0. INTRODUCTION.....	109
5.1. THE ROLE OF FUELWOOD AMONG THE COOKING FUEL TYPES USED IN NIGERIA.....	109
5.1.1. Data Sources.....	109
5.2. DATA ORGANIZATION AND INTERPRETATION	111
5.2.1 Analysis.....	111
5.2.2. Nigerian Cooking Fuel Atlas Using Choropleth Maps	114
5.3. OVERVIEW OF NIGERIAN SPATIAL INTERACTION OF FUELWOOD STUDY USING GWR	116
5.4. EXPLORING SPATIAL VARIATIONS IN NIGERIAN FUELWOOD USAGE	119
5.4.1. Data Sources.....	119
5.4.2. Data Organization and Interpretation.....	119
5.4.3. Pre-Analysis Phase	120
5.4.3.1. Principal Component Analysis (PCA)	124
CHAPTER 6: EXPLORING THE NIGERIAN COOKING FUEL SITUATION USING GIS AND GWR.....	125
6.1. INTRODUCTION.....	125
6.2. THE CONSUMPTION PATTERN OF COOKING FUEL IN NIGERIA	125
6.3. FOSSIL FUEL DISTRIBUTION IN NIGERIA.....	126
6.3.1. Household Kerosene (HHK)	130

6.3.2. Liquefied Petroleum Gas (LPG)	132
6.3.3. Premium Motor Spirit (PMS).....	132
6.4. SPATIAL HETEROGENEITY IN THE CONSUMPTION PATTERN OF FUELWOOD IN NIGERIA	134
6.4.1. The Results of the PCA and OLS Regression Diagnostic Model.....	136
6.4.1.2. Testing the Model Variables Using OLS Regression.....	137
6.4.2. Local Regression Parameter Estimates from the GWR.....	141
6.5. DISCUSSION OF CARTOGRAPHIC AND STATISTICAL FINDINGS.....	144
6.5.1. Fuelwood Versus Other Cooking Fuel Types in Nigeria.....	144
6.5.2. The Strategy of Fossil Fuel Distribution in Nigeria.....	146
6.5.3. The Driving Forces of Fuelwood Consumption in Nigeria	149
6.5.3.1. Current Trends in Unemployment Related Issues	149
6.5.3.2. Corruption and Revenue Allocation in Nigeria	151
6.6. CHAPTER SUMMARY, CRITIQUE AND CONCLUSION.....	152
6.6.1. Chapter Summary.....	152
6.6.2. Chapter Critique.....	153
6.6.3. Conclusion.....	154

CHAPTER 7: METHODOLOGY (LOCAL CAUSES OF VEGETATION CHANGES: FIELD DATA COLLECTION & ANALYSIS OF SURVEY DATA) 156

7.1. INTRODUCTION.....	156
7.2. HOUSEHOLD SURVEY	157
7.2.1. Aims of the Household Survey.....	157
7.2.2. Interview Schedule as a Research Technique	158
7.2.3. Household Questionnaire Design.....	158
7.2.4. Households Pilot Survey.....	160
7.2.5. The Main Household Survey.....	161
7.2.5.1. The Face-to-Face Interview	161
7.2.5.2. The Telephone Interview.....	161
7.2.6. Overall household survey response rate.....	163
7.2.7. Limitation of the Survey Response.....	163
7.2.8. Data Storage and Processing.....	164
7.2.9. Household Survey Data Analysis.....	164
7.2.9.1. Coding the Questionnaire Respondents Responses	167
7.2.9.2. Cross-Tabulation	167
7.2.9.3. Chi Square Analysis	167
7.2.9.4. Stratified Cross-Tabulation.....	169
7.2.9.5. Logistic Regression.....	170
7.3. ETHICAL CONSIDERATION.....	171
7.4. INTERVIEW SCHEDULE CONTINUED (FUELWOOD VENDORS).....	171
7.4.1. Aims of the Fuelwood Vendors Survey.....	171
7.4.2. Questionnaire Design.....	172
7.4.3. Pilot Survey.....	172
7.4.4. The Vendors Survey	173
7.4.4.1. Issues Faced During Vendors Survey (Validation of the Respondents Selection)	173
7.4.4.1.1. Advantages of FGD	174
7.4.4.1.2. Disadvantages of FGD.....	174
7.4.4.2. The Fuelwood Vendors Telephone Interview	175
7.4.5. Limitation of the Survey Response.....	175
7.4.6. Ethical Consideration of the FGD	176
7.4.7. Data Storage and Processing.....	176
7.4.8. Pre-Analysis of Fuelwood Vendors Survey	176
7.4.8.1. Data Coding and Analysis (Qualitative Data Analysis).....	177
7.4.9. Conclusion.....	178

CHAPTER 8: FUELWOOD AS A MAJOR FACTOR IN VEGETATION CHANGE	179
8.0. INTRODUCTION.....	179
8.1. INVESTIGATING HOUSEHOLD INFLUENCE ON THE USE OF FUELWOOD.....	179
8.2. FUELWOOD USE AMONG HOUSEHOLDS	188
8.2.1. Environmental Awareness of Deforestation Among Households	189
8.2.2. Perception of Using Other Modern Cooking Fuel Among Households	192
8.3. DISCUSSION OF RESULTS	194
8.3.1. Fuelwood Consumption in the Study Area	194
8.3.1.1. Fuelwood Procurement and Family Expenditure.....	196
8.3.1.2. Variation in the Use and Price of Fuelwood	198
8.3.2. Reasons for the High Consumption of Fuelwood in the Study Area	201
8.3.2.1. Additional Cooking Fuel Types Use.....	201
8.3.2. 2. Obstacles to using other types of cooking fuel.....	203
8.3.2.3. The willingness to switch Over to Modern Fuel Use	204
8.3.3. How Easily Available is the Type of Fuelwood Preferred in the Study Area?.....	205
8.3.3.1. Types of Wood Used as Fuelwood in the Study Area.	205
8.3.3.2. Distance to Procurement Centres	207
8.3.3.3. Environmental Awareness.....	208
8.4. CHAPTER SUMMARY, CRITIQUE AND CONCLUSION.....	209
8.4.1. Chapter Summary.....	209
8.4.2. CONCLUSION.....	211
 CHAPTER 9: THE STRATEGY OF FUELWOOD SUPPLY - AN OVERVIEW OF COMMERCIAL FUELWOOD ACTIVITIES	 212
9.1. INTRODUCTION.....	212
9.2. STRUCTURE OF COMMERCIAL FUELWOOD VENDING	212
9.2.1. Labour Division	212
9.2.2. Tools Used in Processing Fuelwood in the Study Area	215
9.2.3. Reasons for Participating in the Business	215
9.2.4. Profit of Fuelwood Vending.....	218
9.2.5. Distance to Fuelwood Procurement Centres and the Type of Vehicles Used in Conveying the Goods	219
9.2.6. Price of Fuelwood.....	221
9.2.7. Fuelwood Business and Taxation.....	223
9.2.8. Seasonal Variation in Price and Activities of Fuelwood Procurement	224
9.3. DISCUSSION OF RESULTS	225
9.3.1. Mode of Commercial Fuelwood Operation: A Field Trip Experience.....	225
9.3.1.1. Modes of Fuelwood Collection Operation “Dandi and Da ba”:.....	226
9.3.2. The Fuelwood Business as a Form of Employment Opportunity	230
9.3.3. Transportation System Used in Conveying Fuelwood	231
9.3.4. Seasonal Change and the Orientation of Fuelwood Business	232
9.4. CHAPTER SUMMARY, CRITIQUE AND CONCLUSION.....	234
9.4.1. Chapter Summary.....	234
9.4.2. Chapter Critique	235
9.4.3. Conclusion.....	236
 CHAPTER 10: RECOMMENDATIONS FOR CURTAILING THE PROBLEM OF DEFORESTATION	 237
10.1. INTRODUCTION	237
10.2. LOCAL HOUSEHOLDS PERCEPTION OF THEIR SURROUNDING VEGETATION.....	237
10.3. WAYS OF REDUCING THE EFFECT OF DEFORESTATION	239
10.4. DISCUSSION OF RESULTS.....	241

10.4.1. Reducing the Effect of Deforestation: What is the Current Situation?	242
10.4.1.1. Afforestation Programmes in Nigeria	242
10.4.1.2. Local Efforts in Mitigating the Impact of Deforestation and Fuelwood Supply	243
10.4.1.3. Employment and Poverty Reduction	247
10.4.1.4. Population and Agriculture (Grazing Lands & Some of its Associated Conflicts)	248
10.4.2. Way Forward.....	250
10.4.2.1. Stoves that Could Improve the Use of Fuelwood	250
10.4.2.2. Deforestation Awareness Campaigns	252
10.5. CHAPTER CRITIQUE AND CONCLUSION.....	253
10.5.1. Chapter Critique.....	253
10.5.2. Conclusion.....	253
CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS	255
11.0. INTRODUCTION	255
11.1. CRITICAL REFLECTION ON THE RESEARCH QUESTIONS.....	255
11.2. REFLECTING BACK ON THE RESEARCH PROBLEM	260
11.3. LIMITATIONS OF THE RESEARCH	261
11.4. KEY ACHIEVEMENTS OF THE RESEARCH.....	262
11.5. POLICY IMPLICATION OF THE RESULTS	263
11.6. FINAL THOUGHTS AND FUTURE DIRECTIONS.....	265
BIBLIOGRAPHY	266
APPENDICES.....	288
APPENDIX 1: HOUSEHOLD QUESTIONNAIRE	288
APPENDIX 2: QUESTIONNAIRE FOR COMMERCIAL FUELWOOD VENDORS	291
APPENDIX 3: INTRODUCTORY NOTE AND CONSENT AGREEMENT	294
APPENDIX 4: LAND TENURE SYSTEM IN NIGERIA	295
APPENDIX 5: SOME OF THE NIGERIAN LEGISLATIONS ON THE ENVIRONMENT THAT AFFECTS VEGETATION	296
APPENDIX 6: GRAPHIC OUTPUTS OF THE REMOTE SENSING IMAGE PROCESSING STAGES.....	297

LIST OF TABLES

Table 1.1: Some Socio-Economic Indicators of Deprivation in Nigeria.....	15
Table 2.1: Basic Information about Nigerian Vegetation	28
Table 2.2. Ten Countries with Largest Annual Net Loss of Forest Area, 1990-2010	29
Table 2.3. Energy Reserves, Production and Utilisation in Nigeria.....	42
Table 2.4. An Overview of Fossil Fuel Prices in Nigeria (1973-2012)	50
Table 3.1a: Landsat Satellite Programmes	64
Table 3.1b: Landsat MSS Band Designation.....	64
Table 3.1c: Landsat Tm, Etm+ Band Designation	65
Table 3.2. Simplified Interpretation of an RGB-NDVI Image	73
Table 4.1a: Percentage of Vegetation Area Changed- (RGB-NDVI image 1978-1987)	82
Table 4.1b: Percentage of Vegetation Area Changed- (RGB-NDVI image 1987-2005)	82
Table 4.2: RGB-NDVI Nine Classes Comparative Accuracy Assessment Results Using Fifty Four Random Sample Reference Points	86
Table 5.1: Variable Descriptions and Summary of National Statistics.....	121
Table 5.2: Correlation Coefficients	123
Table. 6.1. Total Variance Explained by the PCA Method	136
Table 6.2. Principal Component Matrix Extraction (3 Components Extracted).....	136
Table 6.3: Summary of OLS_All Results.....	138
Table 6.4: Summary of OLS_ND Results.....	138
Table 6.5: OLS Diagnostics Test Results	138
Table 6.6. OLS Global Moran's I Summary.....	139
Table 6.7. GWR Model Results.....	140
Table 6.8. GWR OLS Global Moran's I Summary	141
Table 6.9. A Summary of the Nigerian Petroleum Retailers in 2006	148
Table 7.1: Response Rate from Household Pilot Survey	160
Table 7.2: Response from Face-to-Face Survey	161
Table 7.3: Response from Telephone survey.....	162
Table 7.4: Overall Total Response from the Household Survey.....	163
Table 7.5: Households' Interview Coding.....	166
Table 7.6: An Example of a 2x2 Fisher's Exact Test Table	168
Table 7.7: Stratified Cross-Tabulation Variables	169
Table 7.8: The Six Groups of Vendors Interviewed and the Dates They Were Interviewed	177
Table 7.9: An Illustration of the Questionnaire Transcripts Coding.....	177
Table 8.1a: Family Size and Fuelwood Use.....	179
Table 8.1b: Employment Status and Fuelwood Use	180
Table 8.1c: Job Type and Fuelwood Use	181

Table 8.1d: Income and Fuelwood Use	181
Table 8.1e: Fuelwood Procurement Method and Fuelwood Use	182
Table 8.1f: Households using Charcoal and Fuelwood Use.....	184
Table 8.1g: Fuelwood Use and Seasonal Variation of Higher Fuelwood Use	184
Table 8.1h: Quantity of Fuelwood Use and Fuelwood Use	185
Table 8.1i: Households using Modern Cooking Fuels and Fuelwood Use.....	185
Table 8.1j: Households Cooking Fuel Choice and Fuelwood Use.....	187
Table 8.1k: Environmental Awareness and Fuelwood Use	187
Table 8.2a: Fuelwood Usage Among Households	188
Table 8.2b: Logistic Regression Analysis for Variables Predicting Households' Use of Fuelwood .	189
Table 8.2c: Vegetation Change Awareness Among Households.....	190
Table 8.2d: Logistic Regression Analysis for Variables Predicting Individual's Awareness of Their Surrounding Deforestation Problems.....	191
Table 8.2e: Households Willingness to Switch to the Use of Modern Cooking Fuel.....	192
Table 8.2f: Logistic Regression Analysis for Variables Predicting Households' Choice to Switch Over to the Use of Alternative Cooking Fuel	193
Table 8.3: List of Preferred Fuelwood Types	205
Table 9.1: The Study Area's Seasonal Variation of Commercial Fuelwood Activities.....	232

LIST OF FIGURES

Figure 1.1: Nigerian Ecological Zones	5
Figure 1.2: The Study Area.....	8
Figure 1.3: Structure of the Thesis.....	17
Figure 2.1: Description of Vegetation Types.....	23
Figure 2.2. Forest Change Dynamics.....	30
Figure 2.3: World Fuelwood Consumption.....	34
Figure 2.4: Comparison of Ecological Regions Production and Demand of Fuelwood in Nigeria (1000m ³).....	36
Figure 2.5: Geographical Distribution of Refineries, Petroleum Products Depots and Petroleum Products Pump Stations in Nigeria.	45
Figure 2.6: Annual Price of Crude Oil	56
Figure 2.7: Multiple Methodologies Used	61
Figure 3.1. A Flow Chart Illustrating the RS Analysis Conducted in this Study.....	67
Figure 3.2: Additive Colour Combinations.....	73
Figure 4.1 (a): Unfiltered RGB-NDVI Resulting Image 1978-1987	78
Figure 4.1 (b): Unfiltered RGB-NDVI Resulting Image 1987-2005	79
Figure 4.2 (a): Filtered RGB-NDVI Resulting Image 1978-1987	80
Figure 4.2 (b): Filtered RGB-NDVI Resulting Image 1987-2005.....	81
Figure 4.3: The Algorithm Used in Assessing the Accuracy of the Result	85
Figure 4.4: Percentage of Vegetation Area Changed Pattern from 1978-2005 (Annual Basis).....	88
Figure 4.5: Percentage of Temporal Variations of Vegetation Area from 1978-2005	88
Figure 4.6: Vegetation Change Pattern in 1978	90
Figure 4.7: Vegetation Change Pattern in 1984	91
Figure 4.8: Vegetation Change Pattern in 1987	92
Figure 4.9: Vegetation Change Pattern in 1999	93
Figure 4.10: Vegetation Change Pattern in 2005	94
Figure 4.11: Vegetation Change Pattern in 1978-2005.....	95
Figure 4.12: Temporal Variations in the Distribution of Vegetation Area from 1978-2005 (Ha)	96
Figure 4.13: Potiskum Town and its Surrounding Vegetation from 1978 to 2005.....	97
Figure 4.14: A Comparative Graph Showing the Pattern of Annual Rainfall with Vegetation Change of the Study Area	99
Figure 5.1: A Flow Chart Illustrating the Descriptive Analysis Conducted in this Study	113
Figure 5.2: WISDOM Modelling Process.....	118
Figure 5.3: Regression Plots showing the Relationship between Fuelwood and the Model Variables	123

Figure 6.1: The Proportion of Cooking Fuel Types Used Among Households in Nigeria	127
Figure 6.2: Percentage of Households Using Fuelwood for their Cooking In the Various States of Nigeria.....	128
Figure 6.3: Distribution of Zones in Nigeria.....	129
Figure 6.4: Nigerian Zonal Population Size and Fossil Fuel Distribution in 2010 ('000 litres)	130
Figure 6.5: Household Kerosene (HHK) Distribution by States in 2010	131
Figure 6.6: LPG Distribution by States in 2010	133
Figure 6.7: PMS Distribution by States in 2010	135
Figure 6.8. OLS Model Spatial Autocorrelation Report Output	140
Figure 6.9. GWR Model Spatial Autocorrelation Report Output	141
Figure 6.10: Spatial Distribution of the Parameter Estimates of Fuelwood Consumption in Nigeria	143
Figure 6.11: The Classic Energy Ladder.....	146
Figure 7.1: Data Collection Process (Survey Model).....	159
Figure 8.1: Annual Fuelwood Consumption Per Head.....	195
Figure 8.2: Proportion of Monthly Spending on Fuelwood Purchase Compared to the Household Monthly Income.....	198
Figure 8.3: Distribution of Modern Cooking Fuel Used Alongside Fuelwood among Households	202
Figure 9.1: Fuelwood Procurement Centres.....	219
Figure 9.2: Structure of commercial fuelwood organisation.....	235
Figure 10.1: Causes of Vegetation Changes.....	238
Figure 10.2: Measures to Combat Vegetation Changes in the Study Area	240
Figure 10.3: A Schema of Stakeholder Involvement in Monitoring Deforestation (Proposed Project)	245

LIST OF BOXES

Box 1.1: Description of Some Socio-Economic Indicators of Deprivation in Nigeria.....	14
Box 2.1: Deforestation and Net Change in Forest Area	30
Box 2.2: Gas Turbines and Wind Resources for Electricity Generation in Nigeria	43
Box 4.1: Accuracy Assessment	85
Box 4.2: A Summary of a Few Sections of the Felling of Trees (Control) Edict, 1986.....	101
Box 6.1: Who Are Nigeria's Boko Haram?	150
Box 8.1: A Simple Description of Almajiri in Northern Nigeria	197
Box 9.1: Wood Collection in Wawa Forest of Gombe State	213
Box 10.1: Views on Nomads/ Farmers Conflict in Nigeria.....	250

LIST OF PLATES

Plate 4.1: An Example of Neem Trees Afforestation Site.....	103
Plate 4.2: Pile of Fuelwood in Potiskum Market.....	106
Plate 8.1: Nature of the Roads Leading to One of the Forests in the Rainy Season.....	200
Plate 8.2: Example of Trees Use for Fuelwood in the Study Area.....	206
Plate 9.1: Processing of Fuelwood in the Market.....	216
Plate 9.2: Photos of the Type of Tools Used in the Processing of Fuelwood	217
Plate 9.3: Photos of the Types of Vehicles Used in Conveying Fuelwood.....	222
Plate 9.4: A visit to Burai Forest.....	227
Plate 9.5: A visit to Wawa Forest.....	228

LIST OF ABBREVIATIONS

Abbreviation	Full Title
AICc	Akaike's Information Criterion
AMAC	Abuja Municipal Area Council
ANOVA	Analysis of Variance
AGO	Automotive Gas Oil
ATA	Agricultural Transformation Agenda
AVHRR	Advanced Very High Resolution Radiometer
AZAP	Arid Zone Afforestation Programme
BBC	British Broadcasting Corporation
BP	British Petroleum
CBN	Central Bank of Nigeria
CIA	Central Intelligence Agency
CFA	Communaute Financiere Africaine
DAPMAN	Depot and Petroleum Products Marketers Association of Nigeria
DC	Developing countries
DFRRI	Directorate for Food, Roads and Rural Infrastructure
DPR	Department of Petroleum Resources
DPK	Dual Purpose Kerosene
ECOWAS	Economic Community of West African States
EM	Electromagnetic
ERS1	European Remote Sensing Satellite 1
ESRI	Earth Systems Research Institute
ESDI	Earth Science Data Interface
ETM+	Enhanced Thematic Mapper Plus
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FCT	Federal Capital Territory
FDF	Federal Department of Forestry
FGD	Focus Groups Discussion
FG	Federal Government
FMA & RD	Federal Ministry of Agriculture and Rural Development
FMANR	Federal Ministry of Agriculture and Natural Resources
FMEN	Federal Ministry of Environment
FORMECU	Forestry Management Evaluation and Coordinating Unit
GCP	Ground Control Point
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GIMMS Global	Inventory Modelling and Mapping Studies
GPS	Global Positioning Systems
GWR	Geographically Weighted Regression Model
Ha	Hectares
HDI	Human Development Index
HHK	Household Kerosene
HoH	Head of the household
HPI	Human Poverty Index
IEA	International Energy Agency
IMF	International Monetary Fund
INEC	Independent National Electoral Commission
IPMAN	Independent Petroleum Marketers Association of Nigeria
JERS1	Japanese Earth Resources Satellite 1
LCCS	Land cover classifications systems

LGAs	Local Government Areas
LFCCs	Low forest cover countries
LNC	Nigeria Labour Congress
LPG	Liquefied Petroleum Gas
MDGs	Millennium Development Goals
MSS	Multispectral Scanner
NALDA	National Agricultural Land Development Authority
NAN	News Agency of Nigeria
NAPIMS	National Petroleum Investments Management Services
NAPEP	National Poverty Alleviation Programme
NARSDA	Nigerian National Space Research and Development Agency
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Statistics
NDA	Niger Dams Authority
NDE	National Directorate of Employment
NDVI	Normalized Difference Vegetation Index
NEAZDP	North East Arid Zone Development Programme
NEN	North Eastern Nigeria
NEPA	National Electricity Power Authority
NERC	Nigerian Electricity Regulation Commission
NESCO	Nigeria Electricity Supply Company
NFP	National Forest Policy
NGC	Nigerian Gas Company
NIR	Near Infra Red
NIRAD	Nigerian Radar project
NNPC	Nigerian National Petroleum Corporation
NOAA	National Oceanic Atmospheric Administration
NPC	National Population Commission of Nigeria
NUPENG	National Union of Petroleum and Natural Gas Workers
OLS	Ordinary least square regression
OA	Output Area
PA	Producer's Accuracy
PCA	Principal Component Analysis
PHCN	Power Holding Company of Nigeria
PMS	Premium Motor Spirit
PPMC	Pipelines and Products Marketing Company
PPP	Purchasing Power Parity
PPPRA	Petroleum Products Pricing Regulatory Authority
PRB	Population Reference Bureau
PTD	Petroleum Tanker Drivers Association
PTDF	Petroleum Technology Development Fund, Abuja, Nigeria
R	Red
RA	Research assistant
RBV	Return beam vidicom
REMP	Renewable Energy Master plan
RGB	Red Green Blue
RMAFC	Revenue Mobilization Allocation and Fiscal Commission
RS	Remote Sensing
SAVAN	Accident Victims of Nigeria
SFDs	State Forestry Departments
SG	State Governments
SEP	Social Economic and Political factors
SPOT	Satellite Pour l'Observation de la Terre

SSA	Sub-Saharan Africa
TIFF	Tagged Image File Format
TM	Thematic Mapper
TOE	Tons of oil equivalent
TUC	Trade Union Congress
UA	User's Accuracy
US	United States
USGS	United States Geological Survey
UN	United Nation
UNDP	United Nations Development Programme
UNSD	United Nations Statistics Division
VIF	variance inflation factor value
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping
WRI	World Resources Institute
WRS	Worldwide Reference System

ACKNOWLEDGEMENTS

I thank Allah for His provisions, protections and support throughout the duration of this programme. I wish to thank my parents for their tremendous contributions and support both morally and financially towards the completion of this project. I would like to express my deep gratitude to my research supervisors, Professor Richard G. Healey, Dr. Peter Collier and Dr. Brian Baily for their patient guidance, enthusiastic encouragement and useful critiques of this research work.

I am obliged to staff members of the Department of Geography, University of Portsmouth for the valuable information provided by them in their respective fields. I am grateful for their cooperation during the period of my PhD. I especially thank Dr. Liz Twigg for guiding me through the design of my questionnaire and the interpretation of some of the statistical results. I would like to thank Dr. Catherine Emma Jones and Paul Carter for their encouragement and suggestions. I am grateful for having Dr. Gina Porter and Dr. Julia Brown as examiners, whose knowledge and suggestions have fine-tuned the overall quality of this work.

My grateful thanks are also extended to the Potiskum central market fuelwood vendors association, the households in Potiskum and Nangere Towns of Yobe state Nigeria, who made available their time to talk to me. I also like to thank my research assistant for organising a telephone interview with the respondents in Nangere town and for his help in arranging other logistics in Nangere and elsewhere after my second field trip was cancelled due to security challenges.

I am also grateful to the Earth Science Data Interface (ESDI) and US Geological Survey (USGS) for providing me with all the remote sensing imageries used in this research. My gratitude also goes to the National Bureau of Statistics (NBS), National Population Commission of Nigeria (NPC) and Nigerian National Petroleum Corporation (NNPC) for providing information used in this project.

I also take this opportunity to thank my father (Alhaji Ibrahim Naibbi- Sarkin Yakin Fika) for funding the initial stage of the project before I secured a funding through the Petroleum Technology Development Fund (PTDF). I am indeed grateful to PTDF for fully sponsoring the PhD for three years.

Finally, I wish to thank my friends and family for their support and encouragement throughout my study. I am obliged to my wife Sa'adatu and my two daughters Ummusalma and Fatima for their understanding and bearing with my prolonged absence.

Chapter 1: Introduction

In most Developing Countries (DC), forest cover is regarded as an open access resource (Linde-Rahr, 2003; Hiemstra-van der Horst & Hovorka, 2009 & Perez-Verdin et al., 2009), which can therefore be overexploited in the present with no regard for the needs of future generations (Chomitz & Griffiths, 2001, p. 285). Chomitz and Griffiths' (2001) observations were in response to the high risk of environmental degradation involved in the process of deforestation. Even though the concept of deforestation is still vague, due to varying definitions of what constitutes a forest (see chapter 2: 2.1.1 & 2.2.2.1); deforestation (vegetation clearance) is mostly attributed to the action of people in their quest for survival (lumbering, expansion of agricultural land, grazing, housing and energy) (Forsyth, 2003, p. 33-36). Among the various reasons that are causing deforestation, fuelwood and agricultural demand are the most important in the DC (Population Reference Bureau (PRB), (2009) & United Nations (UN) Food and Agricultural Organisation (FAO, 2010a)). For example, FAO (2010a, p. 101) showed that about 50 percent of the world's total wood removal in 2005 (3,359 million cubic metres), both from forest and other wooded land areas was attributed to fuelwood requirement.

Fuelwood is a renewable form of energy that has continued to be the only energy option (especially for cooking) for most people in the DC (Aron et al., 1991; Ali & Benjaminsen, 2004; Shackleton et al., 2006; Ghilardi et al., 2007 & 2009 & Maconachie et al., 2009). Results from recent studies of the Nigerian fuelwood situation (see chapters 6 & 8) suggest that the majority of the population has been moving back to the use of fuelwood in recent times. For example, a study conducted in Kano city in Northern Nigeria by Maconachie et al. (2009), which investigates the consumption pattern of fuelwood among households over at least two decades, revealed that most families, despite using other cooking fuels in the past, are now reverting to the use of fuelwood. There are various reasons for this, including among others, poverty and inconsistency in the supply of fossil fuels in the region. These issues are discussed in greater detail in chapters 6, 8, and 10 of this study. Increasing poverty has ever been reported in the developed countries as a driving factor in the use of fuelwood. Arabatzis et al. (2012, p. 6495) reported that because of the economic crisis in Greece, there is an increased consumption of fuelwood, especially in rural areas.

Even though there is now a general consensus about the large scale dependence on fuelwood among households in the DC, some of the early fuelwood investigators (whose fuelwood collection research was focused on family labour), were of the opinion that unless there was a change in the situation, the future demand for fuelwood would be unsustainable due to population increase. Some declared that fuelwood was the most expensive of all energy types, because of its direct potential for ecological damage (Fleuret, 1983; Eckholm et al., 1984; Gill, 1985 & Leach, 1987). For example, Leach (1987) argued that the ring and patches of deforestation observed around some of the major urban areas in the DC are the results of fuelwood collection. Leach's argument suggested that the quest for fuelwood would inevitably take on a new dimension in the future, because of the increased distance required to fetch the fuelwood, as a result of deforestation adjacent to urban areas (vegetation closer to households are insufficient to cater for the increased population demands) (see Christensen et al., 2009 & results of chapters 4, 8 & 9 of this study). However, it should be noted that the recent development of fuelwood supply in the DC contrasts with the situation in the past, where fuelwood collection was solely regarded as the task of women and children (see chapter 9). The concept of deforestation as a result of using small children and women in the procurement of fuelwood has lost favour among researchers, who now argue that the collection of fuelwood using family labour is unlikely to constitute a danger to the environment (Heltberg et al., 2000; Mahiri, 2003; Kaschula et al., 2005; Nash & Luttrell, 2006 & Palmer & Macgregor, 2009).

The incapacity of accessible forests to sustain the high demand for fuelwood results in fuelwood vending. The emergence of commercial fuelwood activities, despite price rises resulting from increased transport costs has been frequently reported as a potential cause of the recent increased rate of deforestation in the DC (Amacher et al., 1996; Adeoti et al., 2001; Mahiri, 2003; Madubansi & Shackleton, 2007; Bearer et al., 2008; Bense, 2008 & Christensen et al., 2009). Nigeria in particular presents a unique situation, because as highlighted in the FAO 2010 forest assessment report, the country recorded the highest percentage of forest loss among the ten top countries with the largest net loss of forest area since 1990 (FAO, 2010a, p.21). The report attributed this to the high demand for fuelwood in the country (see full discussion in chapter 2: 2.2.2 -2.3). This is a major concern to the northern savanna region of the country because this region had already been found to have an unsustainable fuelwood demand as a result of its high

population (refer to figure 1.1 and table 1.1 for more details of the vegetation zones and population of the various regions in the country) (Forestry Management Evaluation and Coordinating Unit (FORMECU), 1996).

Therefore, if deforestation in most of these affected areas (areas where the population solely depend on fuelwood) is to be regulated, the recently changing pattern of fuelwood collection (from using family labour to commercial vendors) requires close monitoring of the commercial fuelwood vendors' activities; through empirical studies (see further discussion in chapters 8 & 9). This view is supported by Forsyth (2003, pp. 33-36), who argued that localised empirical studies are needed in the study of deforestation, and that understanding of the underlying local causes and reasons for deforestation is important, because of the alleged political connotation of the concept among environmental researchers (refer to chapter 2: 2.2.2.1). This study therefore investigates the anthropogenic causation of deforestation using a case study area (see section 1.4), as suggested by Chomitz and Griffiths (2001), in order to avoid large scale generalizations and assumptions (Forsyth, 2003 & Robbins, 2004). Reasons for the choice of the study area are highlighted in section 1.3.

1.1. Aim and Objectives

The aim of this study is to conduct an assessment of changes in vegetation cover in the arid north of Nigeria (North Eastern Nigeria -NEN) where certain parts of the region have been declared susceptible to desertification as a result of deforestation, and to contribute to the ongoing debate on the influence of fuelwood collection and consumption as a factor in deforestation.

The following objectives have been set to achieve the aims identified:

- 1) To use satellite imagery to detect trends and patterns of vegetation change over the period of three decades (1975 to 2005).
- 2) To identify the causes of the vegetation changes observed in the analysed images.
- 3) To highlight the contribution of fuelwood consumption and collection to the vegetation changes observed.
- 4) To identify the socio-economic drivers of fuelwood consumption patterns.
- 5) To propose future policy measures for efficient and sustainable arid zone forestry management.

1.1.2. Research Questions

The following specific questions have been posed in order to meet the research objectives.

- a. What evidence is there of deforestation in the study area, and over what time scales?
- b. What are the possible causes of deforestation in the study area?
- c. If fuelwood is one of these causes, how is it being procured and distributed in the study area?
- d. What is the relationship between fuelwood consumption and the availability and prices of petroleum products?
- e. Does seasonal or protracted fuelwood scarcity have significant socio-economic effects on households?
- f. Is there any government intervention in terms of actions/ policies to address the fuelwood situation especially with regards to avoiding environmental damage, and if so, are there any significant changes as a result of such policies?

1.2. Nigerian Vegetation Zones

The vegetation of Nigeria (figure 1.1) is determined by its climatic conditions, in particular by the rainfall and the severity of the dry season. A comprehensive description of the country's vegetation zones was compiled by Diagnostic Mission (2007, p. 39) and Aregheore (2009), where the following main vegetation zones were distinguished and summarised:

- 1) The Forest Vegetation Zone: This zone comprises; Mangrove forest (coastal vegetation), Freshwater swamp forest and the Lowland Rainforest. The zone's vegetation belt extends from 50 to 250 km wide along the coast. The zone receives a high rainfall that ranges between 1,600 and 2,500 mm per annum. The rainfall lasts for about 10 to 11 months in the year.
- 2) The Southern Guinea Savanna Vegetation Zone: This is a derived savanna vegetation zone with 1,150 to 1,500 mm of rainfall, and a dry season that lasts for 4 to 5 months. It is bordering the north of the forest zone.

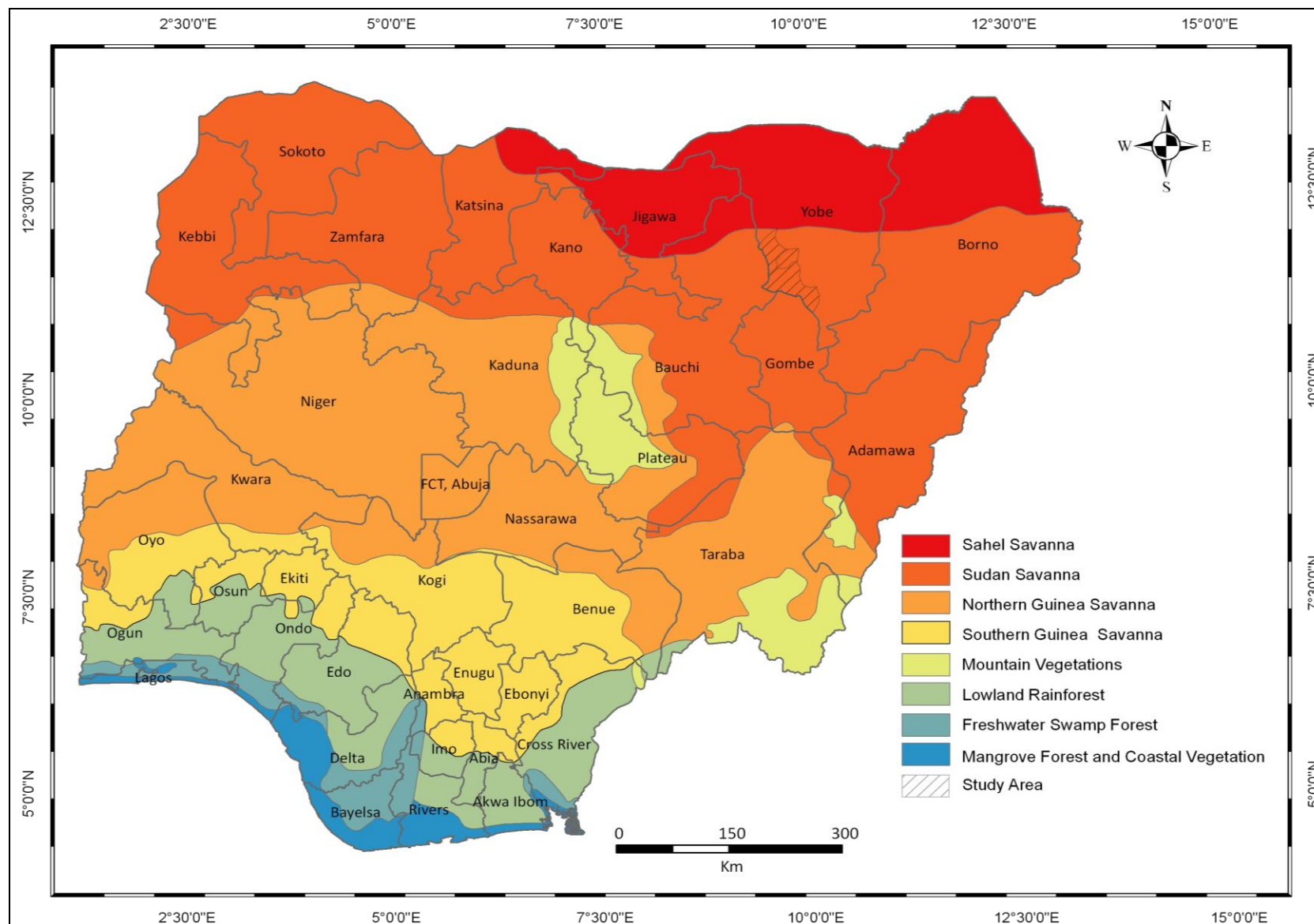


Figure 1.1: Nigerian Ecological Zones

Source: Map Adapted and digitised from FORMECU, (n.d).

- 3) The Northern Guinea Savanna Vegetation Zone: This is a vegetation belt that receives 1,000 to 1,250 mm of rainfall per annum. It has a dry season period that last between 5 and 6 months.
- 4) The Sudan Savanna Vegetation Zone: This area receives 500 to 1,000 mm of rainfall per annum. It has a dry season period that last for 5 to 7 months.
- 5) The Sahel Savanna Vegetation Zone: This area receives an annual rainfall that ranges between 250 and 500 mm, and a dry season that lasts for 7 to 8 months. The zone covers a small percentage of the total area of the country along the north-eastern border with Niger Republic.
- 6) The Mountain Vegetation Zone: Altitude is a dominant factor in the vegetation of this zone. This vegetation zone is seen at higher elevations of the Jos plateau (in the North Central) and in the mountainous area (Mambila plateau) along the central section of the Cameroon border.

These areas, despite being in the middle of the savanna vegetation zones, receive a large amount of rainfall per annum (up to 1,500mm), lasting for about 7 to 8 months in the year. The vegetation of the zone is thicker than the savanna vegetation and the zone is relatively mild in terms of temperature.

1.3. Background to the Case Study

The northern part of Nigeria, which is endowed with a large expanse of arable land, and a huge potential for crop production is being threatened by both climate change and man-made deforestation. This has over the years proven to be the cause of the major decline in vegetation cover in the region. A very popular though unscientific claim, among researchers and policy makers in Nigeria, is that the country, with a total area of 923,768 km², is annually losing about 3,500 km² of its arable land to desertification (encroaching southwards from the north), leading to demographic displacements in some villages across 11 states in the north (Odiogor, 2010). Yobe state is one of the worst affected areas, and Odiogor quoted the Yobe state governor, Alhaji Ibrahim Geidam, emphasising that *“sand dunes are encroaching at a rate of 0.3 km² annually in the northern part of Yobe state; taking over villages (8 Local Government Areas (LGAs) in the northern part of the state were severely affected)”*. While climatic change is very popular among environmentalists, as being the main cause of vegetation decrease in the northern part of

Nigeria, some also believe that the high demand for both agricultural land and fuelwood in the region is a major contributor to the region's vegetation decline (Mortimore & Adams, 2001 & Odihi, 2003). Even though the consumption of fuelwood is undoubtedly high in the region, the work of some earlier researchers exaggerated the situation. A notable example is the work of Bdliya (1987) in Odihi (2003), who reported that the way in which vegetation is being used for fuelwood in some areas of Borno state, would lead to the absence of vegetation cover in the area by 2000, which demonstrably was not the case. While Bdliya's claims did not materialise, some recent global vegetation modelling (using Remote Sensing -RS) of the Sub-Saharan Africa (SSA), has revealed that the vegetation of most areas in the region is increasing (Northern Nigeria inclusive) (Anyambaa & Tucker, 2005 & Olsson et al., 2005). These two contrasting statements require further localised investigation in order to assess the resilience of the region's vegetation.

This study, therefore, investigates Yobe state (an area that falls within those examined by Bdliya, 1987; Anyambaa & Tucker, 2005 & Olsson et al., 2005 and one of the country's known 'hotspots' for vegetation degeneration), using multiple methodologies which include RS, quantitative methods (Geographical Information Systems (GIS) and regression analysis) and the conventional case study approach (mixed methods), in order to determine the extent of current problems within the context of the wider domestic energy situation in Nigeria. The RS study allows the examination of the regional effect of deforestation. GIS and regression analysis are used to explore spatial inequalities in the national distribution and use of modern fuel, while field observations and interviews enable further local assessment of the vegetation cover changes identified using the RS analysis.

1.4. Case Study Area

This study looks at mapping land cover changes in parts of Yobe state, NEN (figure 1.2). Like most Northern Nigerian states, Yobe state is primarily an agricultural area with large expanses of savanna vegetation (Aregheore, 2009). Several areas in the northern part of the state have experienced desertification, which is mostly connected to both climate change and man-made deforestation (Hess et al., 1995 & Odihi, 2003). The southern part of Yobe state including the Potiskum, Nangere and Fika local government areas (Potiskum

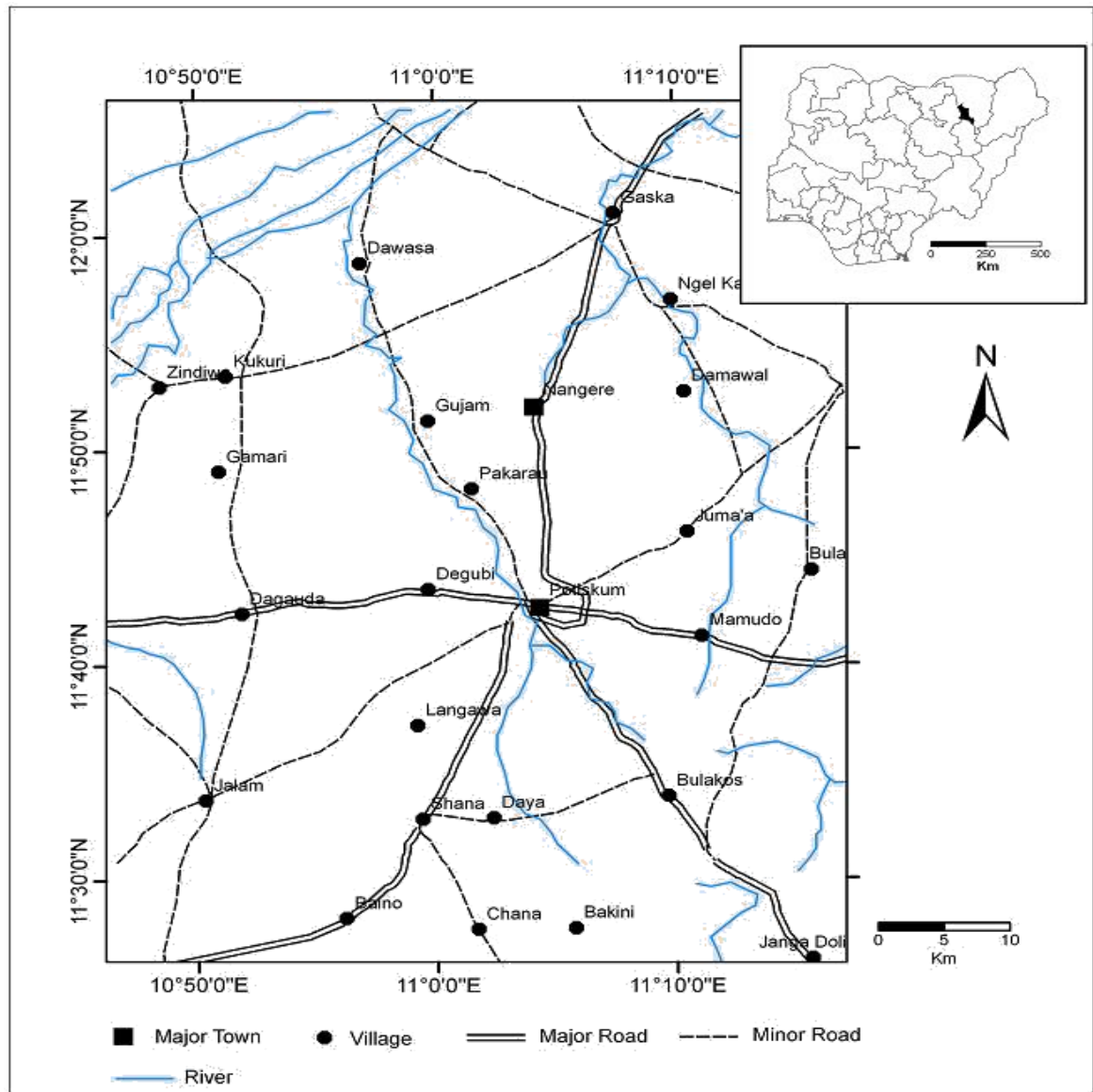


Figure 1.2: The Study Area

and its environs) was selected for investigation here (Latitudes 11°30'33"N & 12°00'00"N & Longitudes 10°50'10"E & 11°14'11"E). The choice of these areas was primarily because they have not previously been examined in the literature on vegetation degeneration and fuelwood consumption in Yobe state. This may be because researchers felt that the area, despite its large population, was less prone to desertification than the northern parts of Yobe state (see figure 1.1 above, Yobe state is covered by two vegetation zones; Sahel Savanna to the north and Sudan Savanna to the south).

The study area falls within the Sudan Savannah vegetation zone (Hess et al., 1995), and is characterised by a hot and dry climate for most of the year (Hess et al., 1995). The hottest months are March, April and May with temperatures ranging between 39° and 42° C. The period of the rainy season in the area varies, but generally lasts for about 120 to 140 days from June to October and ranges between 500mm to 1000mm in total (Hess et al., 1995).

The vegetation zone to which the study area belongs, extends across about 11 of the 19 northern states.

The study area covers approximately 3000 square kilometres, with a population of about 300,000 (National Population Commission of Nigeria (NPC), 2009a). The topography of the study area is relatively flat and the elevation is approximately between 450 to 480 meters above sea level (Hess et al., 1995).

The present author has extensive local knowledge of the study area having lived there for many years. This is very important because the area (at the moment) is a difficult part of the world in which to undertake fieldwork (refer to chapter 6: 6.5.3.1 for more details). Therefore, the choice of the study area has facilitated successful execution of the overall research, because of a pre-existing network of local contacts.

A comprehensive description of the study area's cultural context was covered by Max Lock Group Nigeria (MLGN) (1976). Although MLGN's survey was 37 years older, there were no major changes between their findings and the current cultural status of the study area. Some of the few changes that are obvious are mainly in the area of administration (such as boundary adjustment) and population, which have been covered by Onlinenigeria (2003), NPC (2009a) and Sodeji (2013). The findings of these three sources are summarised below:

1.4.1 History, Population and Ethnicity of the study area

Potiskum town is an old settlement probably reaching over 450 years (MLGN, 1976). Traditionally it was made up of a number of dispersed farming settlements and families with a very loose social pattern. However with the re-organisation of districts between 1914 and 1922, as well as the building of the Bauchi/Maiduguri road and the decision of the colonial administrators to move the headquarters and official residence of the Emir of Fika from Fika (Fika town is about 50Km south of Potiskum) between 1923 and 1924, the town of Potiskum began to take its present shape (MLGN, 1976 & Sodeji, 2013). Since then, it had remained the administrative centre of the region's local authority. Although Potiskum is now a Local Government with headquarters in Potiskum town, the re-organisation of its Local districts (referred to as here as Potiskum and environs) in 1996 created Nangere Local Government Area (with Headquarters at Nangere Town- about 20

km west of Potiskum town) and Fika Local Government Area (with Headquarters in Fika town) (Onlinenigeria, 2003).

Overall, in an economic setting and situation such as Potiskum that is always changing in relation to the population growth, it is almost impossible to make an accurate analysis of employment, income and related subjects. MLGN estimated the total population of Potiskum to be between 55,000 to 60,000 in 1976. However, according to the 2006 census, the population of Potiskum town was 205,876, while that of Nangere and Fika are 87,517 and 136,736 respectively (NPC, 2009a). Presently, Potiskum is the most densely populated area in Yobe state (Sodeji, 2013). The major factor contributing to population change in the area is migration which contributes up to about 2.5% of the estimated 4% average annual growth rate. Traditionally, the major source of migration to Potiskum has been the surrounding districts (consisting of Fika, Potiskum, Nangere and Gadaka-Potiskum and environs) and the surrounding districts in Bauchi, Jigawa and Kano states (MLGN, 1976).

The major ethnic group living in Potiskum includes the Ngizim, Kare Kare, Bolewa, Ngamo, Hausa, Fulani and Kanuri; while Nangere consists of Kare Kare and Fulani; and Bolewa, Kare Kare, Ngamo and Fulani dominate Fika (Sodeji, 2013). However, it should be noted that Potiskum still remained the zonal headquarters of the area.

1.4.2 Cultural background and Religion

The majority of the population of the study area are Muslims, with a small percentage of Christians (Sodeji, 2013). In a typical Muslim family setting like Potiskum and Nangere, the head of the family (Head of Household- refer to chapter 7:7.2 for more detail) is mostly the husband and gaining access to his household exclusively depend on his permission. Typically, he is also responsible for providing the household with their basic requirement (feeding, clothing and shelter) and therefore his decision in most cases on what to use in the house is absolute. Polygamy is also a cultural norm in the study area based on the principles of Islam.

1.4.3 Economy and Trade

Potiskum and its environs are strategically placed in a rich agricultural plain (MLGN, 1976). The town (Potiskum) is on the main Federal Trunk road serving Maiduguri, Bauchi, Gombe and Jigawa and Kano states (MLGN, 1976 & Sodeji, 2013). At the present this road

is the main direct link between Maiduguri (Borno state), Damaturu (Yobe state) and the rest of the Nigerian Federation (Sodeji, 2013). This nodal position of Potiskum makes it an even more strategic marketing and distribution centre. This is one of the reasons for its fast growth to become one of the largest urban areas in Yobe state.

The economic structure of the Nigerian working population naturally reflects Potiskum's economic role (MLGN, 1976 & Sodeji, 2013). The largest single occupational group were those engaged in full-time agriculture. These patterns are similar since the 1970s, which represents over one third of the working population (MLGN, 1976 & Onlinenigeria, 2003). Also many people carry it on as a secondary occupation. Potiskum and its environs are noted for agricultural production through rainfed farming. The area, which lies in the most intensively arable farmed areas in Yobe state produced cereal crops such as millet, Guinea corn, maize, groundnuts and beans. The area is also said to have one of the largest cattle markets in West Africa located in Potiskum town (MLGN, 1976 & Sodeji, 2013). The cattle market is held each week from Wednesday through Thursday, while the Potiskum grains market (also one of the largest in the region) is held every Sunday (Sodeji, 2013).

Trade is the next most important occupation in Potiskum town accounting for almost one fifth of full time occupations. There were a number of major traders as well as small traders or trade employees (Sodeji, 2013). Transportation (Long truck haulage) is also a major business in Potiskum, which is why it had the highest proportion of its working class engaged in commercial Road Transport than any of the other towns in North-Eastern states of Nigeria (MLGN, 1976 & Sodeji, 2013).

1.4.4 Cooking Fuel Energy

At present, about 95% of the households in Potiskum and its environs use fuelwood for their cooking (NPC, 2010). MLGN shows that there were about six forest reserves within a thirty mile radius of Potiskum town in 1976 (three smaller ones to the south- Male Hina, Gudi hill and Janga Siri (Janga Dole); and three larger ones to the north and east- Komadugu Gana (near Gada), Jajeri and Bam Ngelzarma). However, the results of MLGN's survey predicted that these forest reserve areas are likely to be under pressure in the future if the urban population of Potiskum as well as its district continues to expand at its present rate, without any viable substitute to fuelwood. In particular, they emphasised at that time on the continued exploitation of unreserved bush (with its very low

productivity), which appears unsustainable in view of the increasing distance which dealers have to transport their wood from (see more discussion in chapter 9: 9.2.5).

1.5. Background to Socio-Economic Development in Nigeria

Although Nigeria is a wealthy country in terms of human and natural resources, its social and economic development is quite slow. This fact can be illustrated by the country's high level of poverty, lack of basic social infrastructure and above all, the indisputable high level of corruption (Kar & Freitas, 2012). For example, about 65 percent of the country's approximate 160 million people are living below the poverty line (live on less than US\$1.25 a day) (United Nations Development Programme (UNDP), 2009, p.63 & UNDP, 2010, p. 162). The UNDP report further confirmed that the poverty figure in Nigeria (over 90 million people), is higher than the combined population of 10 other West African nations excluding Ghana and Cote D'Ivoire. However, it should be noted that the north, has consistently been disadvantaged in terms of poverty and education in Nigeria since 1980, with the North East zone recording the highest incidence of poverty (UNDP, 2009, p. 63). The situation is the same with the level of unemployment in the country (Eroke, 2012), which again shows the North East to be disadvantaged. Based on the UNDP (2009) report, it can be argued that the current situation of insecurity in the North East zone of the country fostered by Boko Haram (refer to chapter 6: 6.5.3.1 & Amnesty International, 2012), can be attributed to the long term social injustice in the region (see table 1.1). However, the situation in the North Eastern part of the country should not be confused with the overall level of corruption in the country, which has virtually crippled all the public sectors, contributing to unemployment and poverty among the majority of the country's population, while a few segments of the population have become super-rich. It should be noted that the decadence of the country's leadership, has resulted in the deterioration or lack of basic social amenities, including potable water, electricity, health care, educational and recreational facilities and good quality roads among others (Xavier & Subramanian, 2007 & Yakubu et al., 2012). The country is ranked 139 on the list of 176 countries in terms of corruption (Transparency International, 2012). A recent example that supports the aforementioned argument comes from the Ribadu committee report, that was made public on 5th November, 2012. According to the report, the Federal Government (FG) unlawfully spent 51 billion Naira (about £205 million) from the Nigerian National Petroleum Corporation's (NNPC) coffers, on miscellaneous projects, which included among others, buying a presidential jet and sponsorship of Nigeria's

participation in the World Cup (Bisalla & Muhammad, 2012). Now that the report is out, and the people are anticipating government intervention, the same government is trying to hide the report under the carpet. This is one among many examples of how the country's elites continuously divert public money (unaccounted in the national treasury), unlawfully into unnecessary projects for their personal benefit, which is why most of the country's population remain poor.

The level of corruption in Nigeria has also manifested itself among all the energy sectors. The country is experiencing a persistent high cost and irregular supply of fossil fuels, despite several governments' promise(s) of making petroleum products freely available (especially whenever they want to justify price increases- refer to chapter 2: 2.5.1 - 2.5.1.3). Also, the electricity supply (refer to chapter 2: 2.5.2 for more detail) is erratic and of poor quality (Odularu & Okonkwo, 2009 & Olise & Nria-Dappa, 2009). Indeed the electricity supply in the country is so unreliable that people now depend on their own power generators in order to meet their demands. Opara (2013), in a PUNCH Newspaper's edition of January 31st, 2013, reported how the country struggled in 2012 to generate even 5,000 megawatts (MW) of electricity for its 160 million population, as compared to at least, 40,000 MW, which is required to sustain the basic needs of such a population (UNDP, 2010). The electricity generating figures suggest that Nigeria produces less than half of the Ghanaian average, nine times less than the African average, and 22 times less than the world average (Sambo, 2008a & b; Sambo, 2009 & Research & Markets, 2011). Again, the wide deficit margin indicates that the majority of the population lives far below the level of 4,000 kWh per annum required for achieving a decent standard of living (UNDP, 2010). As Sambo (2008b, p. 33) has indicated, the electricity sector in the country would require an annual investment of more than US\$6.46 billion to meet the UNDP's (2010) requirements. However, this is unlikely to happen in the near future, given the level of corruption in the country (Kar & Freitas, 2012). Thus, the population has to depend on the traditional fuel (fuelwood) for their cooking (Maconachie et al., 2009). Table 1.1 and box 1.1 below highlight specific indicators of socio-economic deprivation in the country, which are summarised from a UNDP report (UNDP, 2009, p. 71 & p. 93).

Box 1.1: Description of Some Socio-Economic Indicators of Deprivation in Nigeria

From table 1.1, the human poverty index (HPI) data reveal that poverty is more common in the northern part of the country (with the exception of the FCT, which is the seat of power in the country). Comparatively, all the southern states have a better human development index (HDI) than the northern states. Out of the top 10 states with the highest HDI, eight are in the south; and of the bottom 10 states with the lowest HDI, nine are in the north. The zonal information from the table shows that the South South zone scored highest in HDI with an average score of 0.573. The South West zone is second with 0.523. The North Central zone comes third mainly because of the presence of the FCT. The fourth position goes to the South East. The North East zone comes last with a score of 0.332.

The states with the most pronounced poverty in order of intensity are Yobe, Borno, Kebbi, Katsina, Bauchi, Jigawa, Gombe, Taraba, Kano, and Niger, which are all in the northern part of the country. Certainly, with the exception of the FCT, all the states with the lowest HPI are located in the southern part of the country (p. 91-94).

A selected number of human development benchmarks that are reported in table 1.1 further reveal that adult literacy rate, access to secondary school, access to electricity, access to health services and access to credit facility are all lower in the northern states compared to the southern states.

Since poverty is a major factor in development, it is therefore not surprising to see that the North East zone (which has the lowest human development profile) has the highest HPI with an average score of about 49 per cent.

N.B. The life expectancy for all the zones is fairly close: 51 years for South West; 48 years for North Central, North West and South East; and 47 years for North East and South South.

Source: UNDP (2009, pp. 71 - 95).

From the contents of box 1.1, it was clear that the northern part of the country is the worst affected region in the country in terms of human development deprivation (particularly the North East zone, with Yobe state at the top of the list). This is a further reason why this study focuses on the state.

1.6. Policy Orientation of the Study

The human exploitation of forest resources, especially for fuelwood, had caused serious concerns to environmentalists, who argue that it is among the key factors responsible for vegetation decreases in the Northern Nigeria and elsewhere (Morgan, 1978; Leach, 1987; Schulte-Bisping et al., 1999 & Palmer & Macgregor, 2009). While there are other factors responsible for the decline in vegetation (particularly climate), this study is focussed on the anthropogenic causes of vegetation change, using Potiskum and its environs as a case study. The results will help in developing improved scientific understanding of deforestation and energy poverty in Northern Nigeria, with the hope that policy makers will also find it useful in addressing the complex situation of the Nigerian energy crisis. It is also intended that the findings will be useful to the government in its struggle against deforestation in Northern Nigeria.

Table 1.1: Some Socio-Economic Indicators of Deprivation in Nigeria

Nigerian Geo-Political Zones	North Central States	North East States	North West States	South East States	South- South States	South West States
Distribution of States in each Zone	FCT Abuja, Benue, Kogi, Kwara, Nasarawa, Niger and Plateau	Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe	Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara	Abia , Anambra , Ebonyi, Enugu and Imo	Akwa Ibom , Bayelsa, Cross River, Delta, Edo and Rivers	Ekiti, Lagos, Ogun, Ondo, Osun and Oyo
Population Distribution	Population Size					
	20,369,956	18,984,299	35,915,467	16,395,555	21,044,081	27,722,432
	Total number of Households					
	3,892,927	3,480,963	6,439,578	3,501,533	4,570,095	6,311,989
	Human Development summary statistics ¹					
Human Development Index (HDI) (measured on a scale of 0 to 1)	0.49	0.332	0.42	0.471	0.57	0.52
Human Poverty Index (HPI) (% of total population)	34.65	48.90	44.15	26.07	26.61	21.50
	Nigeria: Core Welfare Indicators ²					
	Household Infrastructure (% of total households)					
Access to Water	80.5	89.4	92.6	63.6	78.5	93.6
Access to Electricity	43.9	29.5	36.9	63.9	61.2	78.1
	Education (% of total population)					
Adult Literacy Rate-Any Language (15-24)	57.9	40.7	51.9	74.7	76.3	78.5
Access to Primary School	78.8	70.2	74.7	59.8	70.3	87.5
Access to Secondary School	46.8	35.3	42.5	31.9	47.1	68.6
	Medical Services (% of total population)					
Access to Health Services:	60.1	47.3	54.2	36.4	44.6	72.3
	Credit Facility					
Access to credit facility	14.5	1.7	2	58.3	46.7	65

¹ Figure from NHDR Team 2008-2009. ² Figures from NBS, (2006); Core Welfare Indicators Questionnaire Survey Report 2006.

Source: Adapted from United Nations Development Programme (UNDP) (2009, p. 71 & p.93).

1.7. Structure of the Thesis

The thesis is structured into eleven chapters, starting with an introduction, literature review, chapters on methodology and empirical results, and ending with the conclusions. The contents of the eleven chapters (figure 1. 3) are briefly summarised below:

Chapter One: This chapter introduces the research topic, by describing human pressure on vegetation particularly in the quest for fuelwood, which is regarded as unsustainable in some areas of Northern Nigeria. It also highlights some of the issues that are contributing to the sluggish development of Nigeria. The chapter further describes the need for the study, and why Potiskum and its environs were chosen as a case study area.

Chapter Two: This chapter reviews the literature relating to the study. It develops the conceptual approach of the study, upon which the subsequent chapters are based. It draws on various research arguments relating to forest, deforestation, fuelwood and the availability of other forms of energy. It also introduces some of the debates relating to vegetation studies. The chapter summarises the findings from the various literature and introduces the need for a multiple methodological approach, given the differing scales of the study objectives (data for the study are sourced from different areas, and are analysed using a different range of approaches. Refer to chapters 3, 5 and 7 for the three methods adopted for the study).

Chapter Three: This chapter describes the Remote Sensing (RS) data and its analysis. The vegetation change detection study uses satellite Imagery and RS modelling techniques, followed by field validation of the results.

Chapter Four: This chapter presents the results of the vegetation change analysis using the RS approach and data from 1978 to 2005. Issues arising from the analysis are also addressed.

Chapter Five: This chapter describes the secondary data sources for the different types of cooking fuels and the reasons for an analytical approach that uses Geographical Information Systems (GIS) and Geographically Weighted Regression (GWR). The data are derived from the various public sector bodies in Nigeria, and are harmonised in a database prior to final analysis.

Title	<i>Fuelwood and vegetation change in Northern Nigeria: an exploration using Remote Sensing (RS), Geographical Information System (GIS) and field reports.</i>
Chapter 1	Introduction chapter: The need for the study; Aim and objectives; Nigerian vegetation zones; Background to socio-economic development in Nigeria; the thesis structure
Chapter 2	<ul style="list-style-type: none"> • Literature review chapter: An overview of vegetation and deforestation; fuelwood and its associated problems; fuelwood vs. other energy types in Nigeria; an overview of RS applications to vegetation change studies; summary of literature review and the need for a multiple methodology approach
Chapter 3	<ul style="list-style-type: none"> • Methodology (RS study): RS application; Data sources; Choice of RS sensors; Image processing and Image enhancement; NDVI; RGB-NDVI classification; RS image results validation (field investigation)
Chapter 4	<ul style="list-style-type: none"> • Vegetation change study using RS: Vegetation change patterns; Mapping the development of vegetation change patterns; Policies regarding afforestation programmes; Deforestation and fuelwood collection; Chapter summary, critique and conclusion
Chapter 5	<ul style="list-style-type: none"> • Methodology (Statistical analysis of aggregate secondary data): Data sources; Data organization and analysis; Nigerian cooking fuel atlas using choropleth maps; Exploring Nigerian fuelwood spatial heterogeneity; Modelling the determinants of fuelwood consumption using GWR
Chapter 6	<ul style="list-style-type: none"> • Exploring the Nigerian cooking fuel situation using GIS and GWR: Consumption pattern of cooking fuel in Nigeria; Fossil fuel distribution in Nigeria; Fuelwood versus other cooking fuel types in Nigeria; The driving forces of fuelwood consumption in Nigeria; Chapter summary, critique and conclusion
Chapter 7	<ul style="list-style-type: none"> • Methodology (Local causes of vegetation changes: field data collection and analysis of survey data): Household survey; Interview schedule as a research technique; Ethical consideration; Semi-structured interview schedule for fuelwood vendors; Issues faced during the vendors survey; data analysis
Chapter 8	<ul style="list-style-type: none"> • Fuelwood as a major factor in vegetation change: Investigating household influences on the use of Fuelwood; Environmental awareness of deforestation among households; Reasons for the high consumption of fuelwood in the study area; Types of wood used as fuelwood among households
Chapter 9	<ul style="list-style-type: none"> • The strategy of fuelwood supply - an overview of commercial fuelwood activities: Structure of commercial fuelwood vending; Distance to fuelwood procurement centres; Fuelwood business taxation; Mode of fuelwood vending operation(a field trip experience); Fuelwood business and employment
Chapter 10	Recommendations for curtailing the problem of deforestation: Ways of reducing the effect of deforestation; Afforestation programmes in Nigeria; Local efforts in mitigating the impact of deforestation and fuelwood supply; Stoves that could improve the use of fuelwood; A schema for monitoring deforestation
Chapter 11	<ul style="list-style-type: none"> • Conclusion and recommendations: Reflecting back on the research questions; Reflecting back on the research problem; Key achievements of the study; Policy implication of the results; Limitations of the Research; Final thoughts and future directions

Figure 1.3: Structure of the Thesis

Chapter Six: This chapter presents the results of the analysis of the Nigerian cooking fuel situation. The consumption patterns of the various cooking fuels are examined to highlight the disparity in their usage between the different parts of the country. The distribution strategy for fossil fuels across the country is investigated to help determine why certain areas of the country use more fuelwood than others. The chapter also reveals some of the socio-economic drivers of fuelwood usage in the country using the GWR model.

Chapter Seven: This chapter describes the primary data collection process (interviews) and issues faced during the field visit. The analytical tools required to understand the fuelwood usage situation among households and their supplying agents (fuelwood vendors) include Quantitative analysis using cross-tabulations and logistic regression, and Qualitative analysis using thematic coding.

Chapter Eight: This chapter presents the results of the household interviews in the study area. Issues facing households in relation to fuelwood usage are identified. Families are having to adapt to the changing cost of fuelwood, and the irregular supply of other cooking fuel sources is affecting most families' willingness to switch over to their use, which results in a tendency to descend the energy ladder. Evidence of the environmental awareness of the population is presented, but necessity is pushing people into depending on fuelwood, despite having knowledge of the future adverse consequences of this course of action.

Chapter Nine: This chapter examines commercial fuelwood activities, and how the vendors maintain the supply of fuelwood to the customers despite being fully aware of how disastrous their action is for the environment. The fuelwood business attracts unemployed people as it primarily involves unskilled manual labour. Also, the urban rich that are well established in the business are shown to be supporting local vendors in a variety of ways. Evidence from personal observations in the field suggests that allegations of bribery surrounding the fuelwood business are well founded.

Chapter Ten: This chapter presents a variety of recommendations for curtailing deforestation problems. These derive from a discussion of the previous findings in the context of the existing literature. Evaluation of the failure of some past fuelwood management programmes leads to a potential solution that is primarily based on

reversion to the old Nigerian forest management strategy that was in operation prior to the 1970s.

Chapter Eleven: This chapter reflects back on the aim and objectives of the study, and draws together the findings of the various chapters. It highlights the key achievements and policy implications of the study, as well as its limitations, and provides recommendations for the future direction of work in this area.

Chapter 2: Literature Review

The study of vegetation change is quite broad and most often related to population increase and environmental degradation. It is not the intention of this study to explore all the environmental issues relating to the causes and consequences of vegetation change, rather the focus will be on deforestation. Therefore, the aim of the literature review chapter is to examine the relationship between vegetation change and the high demand for fuelwood within the Northern Nigerian context as part of wider energy challenges in Nigeria as a whole. The first section of the chapter discusses the general background to the energy situation in Developing Countries (DC). The subsequent sub-sections discuss the concept of vegetation and the forestry situation in Nigeria, as well as the concept of deforestation and the relative position of Nigeria in terms of world deforestation rates. Section 2.3 considers fuelwood, which still remains an important source of cooking energy in Nigeria, and the impact of its use on vegetation resources. Section 2.5 examines energy sources in Nigeria and how supply shortages are hampering the socio-economic development of the country. The last section (2.7) summarises the findings and the gaps identified in the literature that this study investigates further.

2.1. Introduction

Most households in the DC lack access to modern energy types, therefore they rely on the use of traditional biomass fuels like crop waste, dung, and wood to meet their basic energy needs, especially for cooking. This statement was emphasised in the 2005 UNDP's Millennium Development Goals (MDGs) assessment report. The MDGs are sets of time-bound and measurable goals and targets for combating poverty, hunger, illiteracy, gender inequality, disease, and environmental degradation in the world (specifically the DC) by 2015 (UNDP, 2005). In particular, use of wood as a traditional cooking fuel is often regarded as inconvenient, despite being a significant source of energy in most DC (Fleuret, 1983; Eckholm et al., 1984; Amatya et al., 1993; Amacher et al., 1993 & 1996; Mahiri, 2003; Kaschula et al., 2005; Nash & Luttrell, 2006 & Palmer & Macgregor, 2009). A continued high level of fuelwood usage is an alarming situation. Gill (1985) indicated that fuelwood can compete directly with food crops in the DC in terms of demand on household budgets. Leach (1987) pointed out that the massive use and dependence on fuelwood in the DC is environmentally unsustainable (refer to chapter 1: 1.0 & section

2.3.2 below) and therefore regarded it as the most costly of all energy types. Both Gill's and Leach's statements are reflected in the 2011 UNDP MDGs report (BBC Hausa, 2011b), which highlighted the failure of some of the participating countries to meet the targets of the MDGs as expected.

The 2011 UNDP assessment of the MDGs has included Nigeria among those countries requiring further effort to improve their energy situation. Anozie et al. (2007, p. 1284) highlighted some of the efforts of the Nigerian government through its Energy Commission and the numerous other research contributions in addressing the energy situation. They concluded that the majority of the energy targets set by the government remained unmet, due to lack of policy implementation, general lack of awareness from consumers of the compelling need to conserve energy and lack of logistics and proper funding. All the four impediments to the improvement of the energy situation in Nigeria described by Anozie et al. (2007) focused on the laxity of the policy makers in either not funding the sectors efficiently or not policing the laws that would regulate the proper use of energy in the country. It is against this background that it is appropriate to provide an academic assessment of the salient issues in the Nigerian energy situation with particular emphasis on the traditional energy (fuelwood) situation, as wood is the major source of cooking energy for the households (Sambo, 2005 & FAO, 2011a).

2.1.1. Vegetation

The key focus of this study is the relationship between vegetation change and fuelwood usage. Therefore, a broader definition of vegetation and where this study falls within this definition is quite important (given the broader concept of vegetation) in order to provide a context for the study. Land cover is the observed bio-physical cover on the earth's surface (Di Gregorio & Jansen, 2000, p.3). This definition incorporates both natural and manmade features on the earth surface as land cover. There have been numerous land cover classification systems (LCCS) that have resulted in either classifying only natural vegetation types, agricultural areas or broad land cover classification types (Di Gregorio & Jansen, 2000). The differences in the resulting classification systems derived from differing organisational requirements. Di Gregorio and Jansen (2000) designed a multi-user-oriented classification system that resolves discrepancies between the various organisational classification systems, through a process of standardisation.

In the initial phase of their classification they identified major land cover types, as follows;

- Cultivated and Managed Terrestrial Areas
- Natural and Semi-Natural Terrestrial Vegetation
- Cultivated Aquatic or Regularly Flooded Areas
- Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation
- Artificial Surfaces and Associated Areas
- Bare Areas
- Artificial Water Bodies, Snow and Ice
- Natural Water Bodies, Snow and Ice

The eight major land cover types identified in their classification were tailored to the presence or absence of vegetation in terms of primarily vegetated and primarily non-vegetated areas. They describe the primarily vegetated areas as areas with a vegetative cover of at least 4% for at least two months of a year. While the primarily non-vegetated category comprises cover areas with a total vegetative cover of less than 4% for more than ten months of the year. The second phase of the classification categorised vegetated areas into four broad classes each with subclasses contrary to the conventional way of classifying vegetated areas as mentioned earlier. The main domains are:

- Grasslands: defined as plants without persistent stem or shoots above ground and lacking definite firm structure (Scoggan, 1978 in Di Gregorio & Jansen, 2000, p.87).
- Shrublands: defined as plants with persistent woody stems and without any defined main stem structure (Ford-Robertson, 1971 in Di Gregorio & Jansen, 2000, p.86).
- Woodlands: defined as perennial plants with stem(s) and branches from which buds and shoots develop (Ford-Robertson, 1971 in Di Gregorio & Jansen 2000, p. 86).
- Forest: defined as perennial plants where trees cover more than 10 percent of the ground (Wright & Muller-Landau, 2006).
- Trees: defined as woody perennial plants with a single, well defined stem carrying a more-or-less-defined crown (Ford-Robertson, 1971 in Di Gregorio & Jansen, 2000, p. 86) and being at least 3 to 5 m tall (Di Gregorio & Jansen, 2000, p. 86 & Wright & Muller-Landau, 2006, p. 289).

A summary of Di Gregorio and Jansen's final phase of vegetation classification approach is presented in figure 2.1.

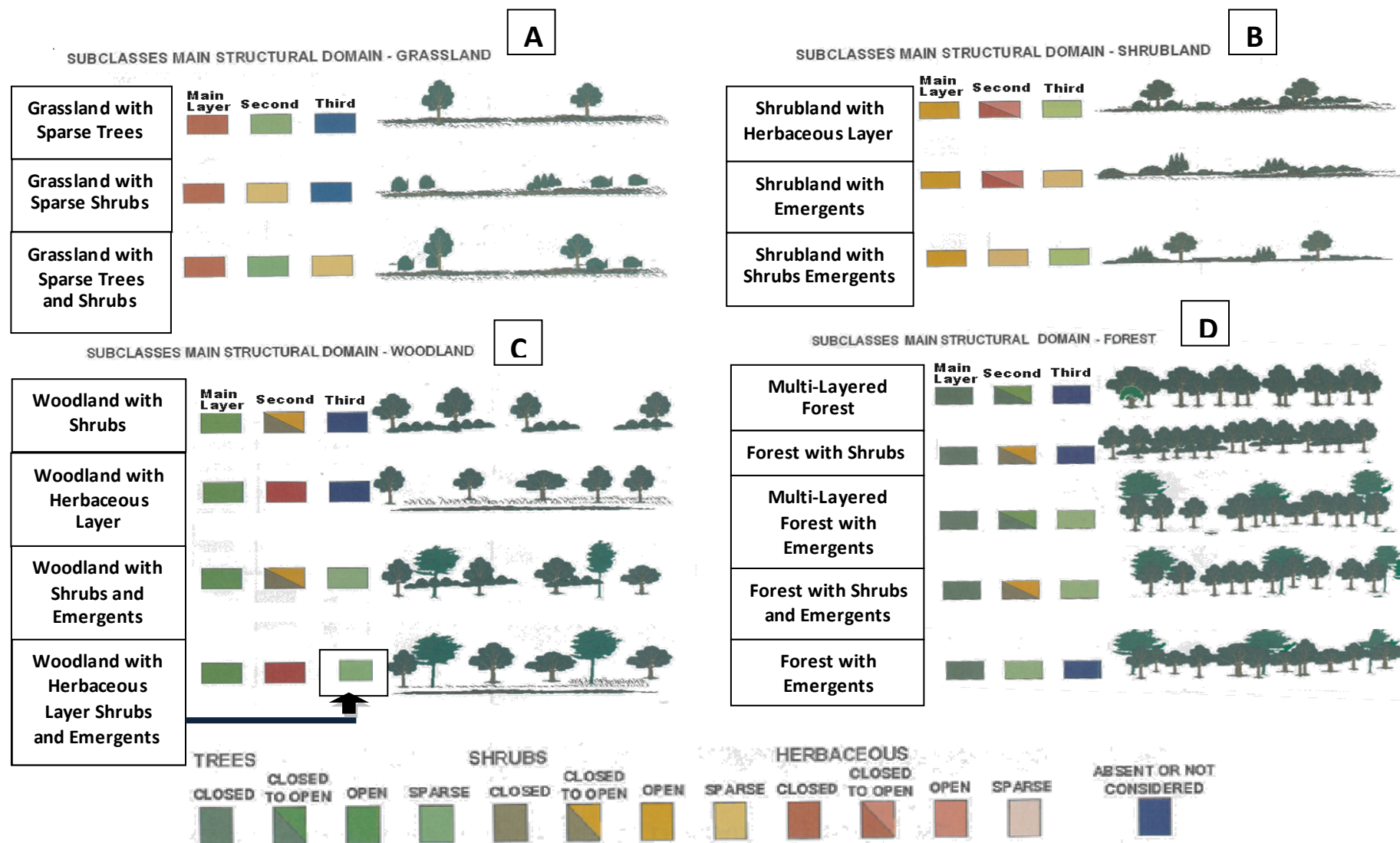


Figure 2.1: Description of Vegetation Types

Source: Adapted from Di Gregorio and Jansen (2000, pp. 163-168).

The subclasses (third phase of the classification) are described using the mixture of one or two of the main domains. The layers are described using a further sub-division in terms of closeness of the land cover types to each other as follows: Closed (> 60-70 percent are trees or shrubs with crowns interlocking, touching, or slightly separated); Open (between 70 to 60 percent (open) and 20 to 10 percent (very open) are trees or shrubs with the crowns not interlocking); and Sparse (between 20-10 percent (sparse) and 4 to 1 percent (scattered), in terms of plant cover (p. 22)).

The vegetation of this study area includes woodlands, trees, shrubs, herbaceous or a combination of either two or all of these (see figure 2.1). This is broadly identified as part of the savanna vegetation region (Hess et al., 1995, FAO, 2003 & FAO, 2009b). Rainfall lasts for about 5 months in a year (Hess et al., 1995), while the vegetation cover is over 4% (FAO, 2010b). Based on these facts, the area is considered to match the category of Sparse Woodland with Herbaceous Layers, Shrubs and Emergents (see figure 2.1 C) under the Di Gregorio and Jansen (2000) classification.

2.2. Overview of Forestry System in Nigeria

FAO recommends that every country should have forest covering at least 25 % of its total land area (FAO, 2010a); Nigeria has only 10% of its land area covered by forest and therefore does not meet this recommendation. For that reason, Nigeria is categorised among the countries referred to as low forest cover countries (LFCCs) (FAO, 2003 & FAO, 2010a). Furthermore, even within the 10% of land under forest, studies have shown that only about 1.3% of the country's total land area (12,114 kilometre square) is considered undisturbed forest cover (FAO, 2003). This is an indication of how extensively the vegetation cover is utilised. A detailed history of Nigeria's forestry programmes is provided by FAO in its 2003 report entitled "*experience of implementing national forest programmes in Nigeria*". The report is discussed in sections 2.2.1 and 2.2.1.1 below.

2.2.1. History of Forest Management in Nigeria

The beginning of forest management in Nigeria dates back to 1887 when the office of woods and forest was opened in the then colony and protectorate of Lagos. The first forest decree came into effect in 1901. The decree was fashioned in 1916 with the aim of regulating the sale of timber and improvement of revenue through taxation. It also regulated the minimum girth allowed for exploitation (only mature trees of 100cm and

above girth could be removed) and it mandated users to plant 20 more tree seedlings at each stump site. This was the practice up until 1926 when artificial regeneration through the “*Taungya*” system (a system of agriculture where crops are produced alongside with trees) was introduced. By 1940, forest reservation areas were completed in the high forest areas in Southern Nigeria, with the exception of Rivers state, where more areas were set up between 1960 and 1980.

The development of the forest area reserves was, however, much later (between 1950 and 1970) in the northern part of the country where savanna vegetation dominates. The slow and late development of forest reserves in the northern part of the country could be due to the unimportance of savanna vegetation to the export trade in forest logs, which was then very popular in the higher forest of the south.

After the country was divided into three administrative regions in 1954, each region was given the responsibility for the administration, monitoring, management and control of its forest resource, while the Federal Government (FG) was responsible for forestry research and institutions. A similar situation persists even today among the thirty six states and the Federal Capital Territory (FCT), where each state is tasked with the responsibility of safeguarding and controlling its forest areas. This pattern of control is the reason why the FG has no forest reserves of its own.

Prior to the 1970s, forest reserves embraced the activities of local communities, who were authorised to continue their former use of the forest as long as their practices did not affect timber production and forest management. This helps explain why, in the early period, forests in Nigeria, were managed with a high degree of effectiveness. In recent times, by contrast, especially after the Land Use Decree of the late 1970s (which emphasised that all land belongs to government; see full discussion of Nigerian land tenure system in appendix 4), the efficiency of the sector began to deteriorate like most other public sectors in the country. By the mid 1980s, forest reserves were not properly maintained while management plans were either non-existent or abandoned.

2.2.1.1. The Present System of Forestry Administration in Nigeria

Forestry activities in Nigeria are administered through the three tiers of Government i.e. Federal, State and Local Government. At the federal level, the Federal Ministry of Environment (FME), which was created in 1999, is responsible for administering forestry

at the national level through the Federal Department of Forestry (FDF). The latter was created in 1970 under the Federal Ministry of Agriculture and Natural Resources (FMANR). FDF was transferred from FMANR to FME in 1999 and mandated with formulating National Forest Policy and supporting the execution of projects funded by the FG. Other mandates of the FDF include advising and assisting the State Forestry Departments (SFDs) on certain national projects and contacts with international development agencies who assist Nigeria with funds and advice. The states are responsible for their forestry administration through the SFDs under the States' Ministries of Environment. At present, most states have forest reserves maintained by the SFDs, which are responsible for the technical functions of managing timber and wildlife resources, and revenue generation through taxation from the forestry sectors in their states. The smaller forestry departments in the Local Government Areas (LGAs) have the following mandates in the new National Forest Policy (NFP):

- A) Setting up of wood lots to protect watersheds and river courses;
- B) Protection of forests and farm trees in arable land against fire and illegal felling of trees; and
- C) Protection of wildlife against poaching.

Having said earlier that the country operates a unified system of forestry operations through the three tier system of government, in reality there is a difference in the mode of operation between the north and the south. This is because the focus of administrative and forestry staffs in the SFDs and LGAs differs from the north to the south. LGAs in the south have virtually no responsibility for managing their forest resources, but may receive part of the revenue generated from forest produce by the SFDs. In the north, the functions of LGA forestry services include revenue generation and forest preservation. The staff in the south where the high forests exist focused on log harvesting, while in the north, where a dispersed forest type dominates (savanna vegetation), they concentrate on the importance of forest resources for fuelwood, environmental protection and livestock production. Unfortunately, even with the new NFP that provides guidelines for safeguarding the forest areas and their resources, starting from the smallest unit of administration (LGAs) in the country, both SFDs and LGAs are faced with a lack of funds and personnel to carry out their tasks effectively. The few staff available also lack adequate training and exposure to modern forestry techniques (FAO, 2003 & FAO, 2010b).

One key problem in the north is the lack of comprehensive documentation of its forestry activities compared to the south (FAO, 2003). Over emphasise on the south, particularly in most FAO reports, is the result of attention being focussed on the high forest areas of the south, which has left the less vegetated areas in the north neglected despite the pressing need for research there.

It is worth noting that even though there is an NFP in Nigeria (which was revised in 2006), there was no such forest policy at state level. In contrast, the states were allowed to establish their individual forest laws according to their needs (FAO, 2010a, p. 300) - (see example in chapter 4: 4.2.3).

2.2.2. Vegetation Change

Table 2.1 provides a summary of some basic information about the state of Nigerian vegetation. From this table, it is apparent that Nigerian forest cover has consistently declined since the 1990s, at an average of -410,000 hectares (ha) per annum. FAO (2009a) reported that about 60 percent of the world's total wood removals (3,900 million cubic meters) from forests and trees outside forests are used for energy purposes (refer to table 2.1 for Nigerian situation).

At the global level, the total net change in forest area (see box 2.1 below) in the period 2000–2010 is estimated at -5.2 million ha per year, which is equivalent to a loss of more than 140 square kilometres of forest per day (FAO, 2010a, p. 17). FAO maintain that this figure is lower than the total forest net change obtained from 1990 to 2000 (-8.3 million ha per year).

Similarly, the area of other wooded land decreased by about 3.1 million ha per year during the decade 1990 to 2000 and by about 1.9 million ha per year in the last decade (2000–2010) (FAO, 2010a, pp. 21-22). It is argued that the slower recent rate of decline is as a result of setting up of more plantations rather than a reduction in deforestation (Mather, 2003 & FAO, 2010a, p.17). Another possible reason for the apparently slower decline could be due to more studies using Remote Sensing (RS) techniques (Mather, 2003), that have been used to construct a more accurate global forest cover map. Earlier reports by researchers in the field of deforestation had a tendency to exaggerate the forest change situation (Forsyth, 2003). However, some environmental groups have expressed concerns about reaching such conclusions about reductions in the rate

Table 2.1: Basic Information about Nigerian Vegetation

Demographic data of Nigeria									
Land area ^a (1 000 ha)		Population (2008) ^b			GDP (2008) ^c				
	Total (1 000)	Density (Population/km 2)	Annual growth rate (%)	Rural (% of total)	Per capita (PPP) (US\$) ^c	Annual growth rate (%)			
91 077	151 212	166	2.4	52	2 099	6			
Extent of forest and other wooded land 2010									
Country area (1 000 ha)	Forest		Other wooded land Area						
	area (1 000 ha)	% of land area	area (1 000 ha)	% of land area					
92 377	9 041	10	4 088	4					
Trends in extent of forest 1990–2010									
Forest area (1 000 ha)				Annual change rate					
1990	2000	2005	2010	1990–2000 (1 000 ha/year)	% ^d	2000–2005 (1 000 ha/year)	% ^d	2005–2010 (1 000 ha/year)	% ^d
17 234	13 137	11 089	9 041	-410	-2.68	-410	-3.33	-410	-4
Trends in removals of wood products 1990–2005									
Industrial round wood - Total volume (1 000 m3) ^e				Wood fuel - Total volume (1 000 m3) ^e					
1990	2000	2005		1990	2000	2005			
9 321	10 831	10 831		59 095	68 172	70 427			
Value of wood removals (Five year average for 2003–2007)									
Value of removals (million US\$)									
Industrial round wood ^f	Wood fuel ^f								
124	456								

^a Total area of the country excluding inland water bodies. The figures are from FAOSTAT (FAO, 2008). ^b General Source: FAOSTAT-PopSTAT (<http://faostat.fao.org/site/550/default.aspx#ancor>). ^c Per capita gross domestic product (GDP) is expressed at purchasing power parity (PPP). Source: World Bank (2010), IMF (2010); UNSD (2010) and CIA (2010). ^d Rate of gain or loss in percent of the remaining forest area each year within the given period. ^e Five year averages for 1988–1992, 1998–2002 and 2003–2007 respectively. ^f Five year average for 2003–2007. Source: Adapted from FAO (2010a).

N.B. The figures for 2000 and 2005 of industrial round wood under Trends in removals of wood products 1990–2005 appear the same because of the effect of rounding the total figures to the nearest 1000. However, it is an indication that the variation in the industrial wood removal is quite small since 1990 compared to wood fuel.

of deforestation because of the fear that they can lead to a slowing down of active programmes against deforestation (Mather, 2003). In terms of regional net loss of vegetation, South America accounted for the largest proportion of the net loss, followed by Africa and Asia (FAO, 2010a). Table 2.2 below shows that Nigeria is among the top five countries in the world with the largest net loss of forest areas since 1990. This is not surprising, given that the majority of the country's wood removal is for fuelwood (see table 2.1). The country is moving back to the use of traditional cooking energy, which is why the volume of fuelwood collection rose from about 59,095,000 m³ in 1990 to about 70, 427, 000 m³ in 2005 (see table 2.1).

Table 2.2: Ten Countries with Largest Annual Net Loss of Forest Area, 1990-2010

Country	Annual change 1990–2000		Country	Annual change 2000–2010	
	1 000 ha/yr	%		1 000 ha/yr	%
Brazil	-2 890	-0.51	Brazil	-2 642	-0.49
Indonesia	-1 914	-1.75	Australia	-562	-0.37
Sudan	-589	-0.8	Indonesia	-498	-0.51
Myanmar	-435	-1.17	Nigeria	-410	-3.67
Nigeria	-410	-2.68	United Republic of Tanzania	-403	-1.13
United Republic of Tanzania	-403	-1.02	Zimbabwe	-327	-1.88
Mexico	-354	-0.52	Democratic Republic of the Congo	-311	-0.2
Zimbabwe	-327	-1.58	Myanmar	-310	-0.93
Democratic Republic of the Congo	-311	-0.2	Bolivia	-290	-0.49
Argentina	-293	-0.88	Venezuela	-288	-0.6
Total	-7 926	-0.71	Total	-6 040	-0.53

Source: FAO (2010a p. 21).

2.2.2.1. Deforestation

Box 2.1 and figure 2.2 below illustrate the concept of deforestation in simple terms. Despite the huge interest in the study of deforestation among researchers, there are still controversies in the literature related to the definition of the term mainly because of the lack of standard definitions of what is a forest (Middleton, 2008, p. 57). Wunder and Verbist (2003) and Middleton (2008) noted that according to FAO there are over 650 different definitions of a forest. The variation in the definitions is a consequence of the differences in the perception of the concept by the various countries whose data FAO relied upon for the forest assessments (refer to Middleton, 2008, p. 58). Interestingly, despite these huge differences, FAO was able to provide a comprehensive definition of

Box 2.1: Deforestation and Net Change in Forest Area

Figure 2.2 is a simplified model illustrating forest change dynamics. It has only two classes: forests and all other land. A reduction in forest area can happen through either of two processes: deforestation and natural disasters. Deforestation, which is by far the most important, implies that forests are cleared by people and the land converted to another use, such as agriculture or infrastructure. Natural disasters may also destroy forests, and when the area is incapable of regenerating naturally and no efforts are made to replant, it too converts to other land.

An increase in forest area can also happen in two ways: either through afforestation (i.e. planting or seeding of trees on land that was not previously forested), or through natural expansion of forests (e.g. on abandoned agricultural land, a process which is quite common in some European countries).

Where part of a forest is cut down but replanted (reforestation) or grows back on its own within a relatively short period (natural regeneration) there is no change in forest area.

N.B. Net forest change is the sum of all negative changes due to deforestation and natural disasters and all positive changes due to afforestation and natural expansion of forests.

Source: FAO (2010a, p.17).

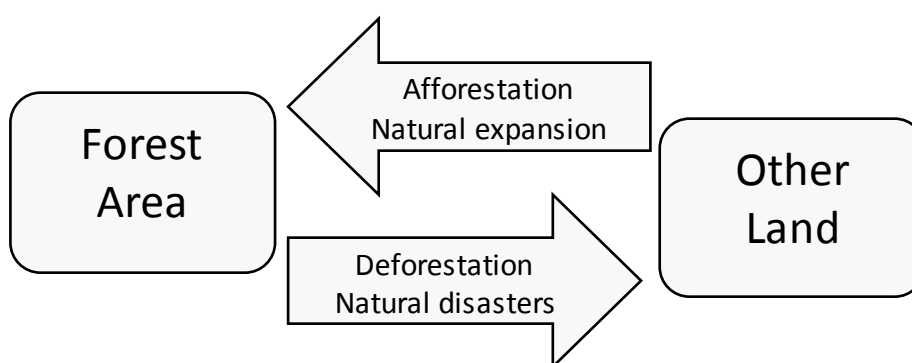


Figure 2.2: Forest Change Dynamics

Source: FAO (2010a, p.17).

the term “forest” as an area of a minimum 0.5 ha, covered by a tree canopy of at least 10 percent, with trees that can reach 5 meter height, and subject to the constraint that the area should not be under an alternative (e.g. agricultural or urban) use (FAO, 2000).

From the definition, it can be observed that FAO considered both natural forests and forestry plantations as “forests” as long as they satisfy the quantitative criteria. Based on this definition, deforestation is considered to be the removal of tree cover from the forest- or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold (FAO, 2010a). On the other hand, authors like Forsyth (2003) and Middleton (2008) regarded the term “deforestation” as the conversion of a forest area to another land use, mainly by clearing the existing vegetation cover. This latter definition of deforestation seems more accommodating, because of the inclusion of the “phrase” clearing of the existing vegetation cover’ in the definition. Forsyth (2003, p. 36) argues

that this enables other forest ecosystems, such as the savanna to be considered also. Given this fact, Forsyth's definition is adopted in this study, since it allows the inclusion of other vegetation types that are being cleared for various reasons. Since the FAO definition of deforestation is more rigid and confined to a specific definition of forest (tree canopy of at least 10%, with trees up to 5 meter height), it is not utilised in this study.

Neither definitions ignored the fact that deforestation has been attributed to the action of human beings (refer to box 2.1). It is also important to distinguish between the clearance of different types of vegetation cover (forest, woodland, savanna, shrubland and grassland) instead of treating all kinds of vegetation the same. This is because the extent of wood extraction differs from one ecosystem to another based on a variety of factors.

For example, Amacher et al. (2009) examined the implications of migration and insecure property rights for land use and deforestation in the tropical frontier forests. The authors concluded that illegal logging risks lead to deforestation. Even though they reported a decrease in forest cover in their study as a result of illegal logging, they also highlighted the complex nature of the concept of deforestation because, in their study area, government enforcement of forestry legislation reduced illegal logging, while greater private enforcement did not necessarily reduce deforestation. This shows the importance and the need for government intervention in the management of forests (see more discussion in chapters 9 & 10). They also reported, as would be expected, that forest with higher economic value are more subject to active deforestation. This applies, in the case of Nigeria, where the accelerating rate of vegetation clearance since 1990 has been attributed to the demand for fuelwood (refer to table 2.1).

2.3. Fuelwood

Fuelwood, charcoal and animal dung/sawdust are all biomass products (Sambo, 2009). Charcoal is a direct by-product of fuelwood and will therefore be discussed as a type of fuelwood resource in this study. Although Animal dung/sawdust forms part of the energy resource for household cooking in Nigeria, its use is insignificant (Sambo, 2009) compared to other cooking fuel types in the country and therefore it is not considered further here.

2.3.1. The Shortage of Fuelwood

In the past, rising fuelwood demand was predicted to result in a whole range of negative environmental and socio-economic consequences, including persistent depletion of forest resources, increased wood collection times, and greater monetisation of fuelwood supplies requiring more cash from poor households (Hyman, 1993). Most of these negative perceptions were particularly pointed out by Eckholm (1975) in the late 1970s and emphasised by Eckholm et al. (1984) in their work entitled *“Fuelwood: The energy crisis that won’t go away”*. Throughout the 1970s and a greater part of 1980s, the security and future sustainability of fuelwood demand was questioned, based on the assumption that in the near future, the majority of places in the DC would be deforested as a result of fuelwood collection (Gill, 1985 & Schulte-Bisping et al., 1999). These assumptions and predictions were mostly based on very crude estimates and projections of supply and demand, so further empirical studies were needed to assess the fuelwood situation more accurately (Eckholm et al., 1984).

Eckholm et al. (1984) suggested that research interventions should focus more on the underlying causes of the fuelwood problem rather than just on the symptoms. This has paved the way for much research on the present use of and future prospects for fuelwood supplies. Notable studies include Mahiri and Howorth (2001); Ali and Benjaminsen (2004) and Bense (2008). These cast doubt on Eckholm et al.’s (1984) earlier prediction of a future fuelwood crisis, and they have concluded that local fuelwood collection (using family labour) is not the primary cause of deforestation. Other contributing factors include forest clearance for agricultural land, housing construction, overgrazing and overpopulation, which vary in importance between different localities (refer to chapter 10: 10.2 for the situation in the study area). However, they have all identified the importance of commercial fuelwood demand, in particular, as a potential contributor to over-exploitation of forest resources (the commercialisation of fuelwood is discussed under section 2.4 and chapters 8 and 9).

Some other studies have clearly shown fuelwood collection to be the major cause of deforestation, especially at a local level. For example, Amacher et al. (1996; 1999); Ghilardi et al. (2009) and Palmer and Macgregor, (2009) have shown that the demand for fuelwood in their respective study areas (Nepal, Central Mexico and Namibia respectively) can only be met by the overexploitation of forest resources. A similar situation was

observed much earlier in Botswana where the majority of the people were aware that sooner or later, acquiring firewood would become a very difficult task, based on their observations of the rate at which trees are fast disappearing (Jelwic & Van Vegtan, 1981). Unfortunately, none of these studies paid close attention to the size of the forest resource that had been overexploited as a result of fuelwood collection, so they were unable to show clearly the extent of the resulting forest degradation. It is therefore important to study the present and likely future impacts of fuelwood collection in relation to the forest size and/ or pattern of vegetation change, especially at a sub-regional level.

2.3.2. Fuelwood Consumption

Figure 2.3 below shows the natural shares of world fuelwood consumption. The wood energy considered in the statistic includes fuelwood, charcoal and black liquor¹, which are measured in thousand metric tons of oil equivalent (TOE) - (1 metric TOE is defined as 41.868 Gigajoules which is equal to the amount of energy contained in 1 metric tonne of crude oil; 1 tonne of Fuelwood = 0.38 TOE).

From figure 2.3, it is obvious that the DC use more fuelwood than the developed countries, with most countries in Asia and Africa using fuelwood for at least 50% of their energy consumption. In contrast, the developed countries (Europe and North America) derive less than 10% of their energy needs from fuelwood. The major problem in the DC is the lack of viable alternative energy sources in the DC that could reduce the number of people that depend on fuelwood (Maconachie et al., 2009 and see the discussion of chapters 6, 8 & 10). The adverse effect of this is borne by the environment in the form of deforestation.

Studies of fuelwood conducted in different parts of Nigeria (major towns) that explored the patterns of use and change over time revealed an extending and changing exploitation pattern of fuelwood resources. Cline-Cole et al. 1987; Hyman 1993 and 1994;

¹ A by-product of the papermaking process, it is an important liquid fuel in the pulp and paper industry, which consists of the remaining substances after the digestive process where the cellulose fibres have been cooked out from the wood- (Marklund, n.d).

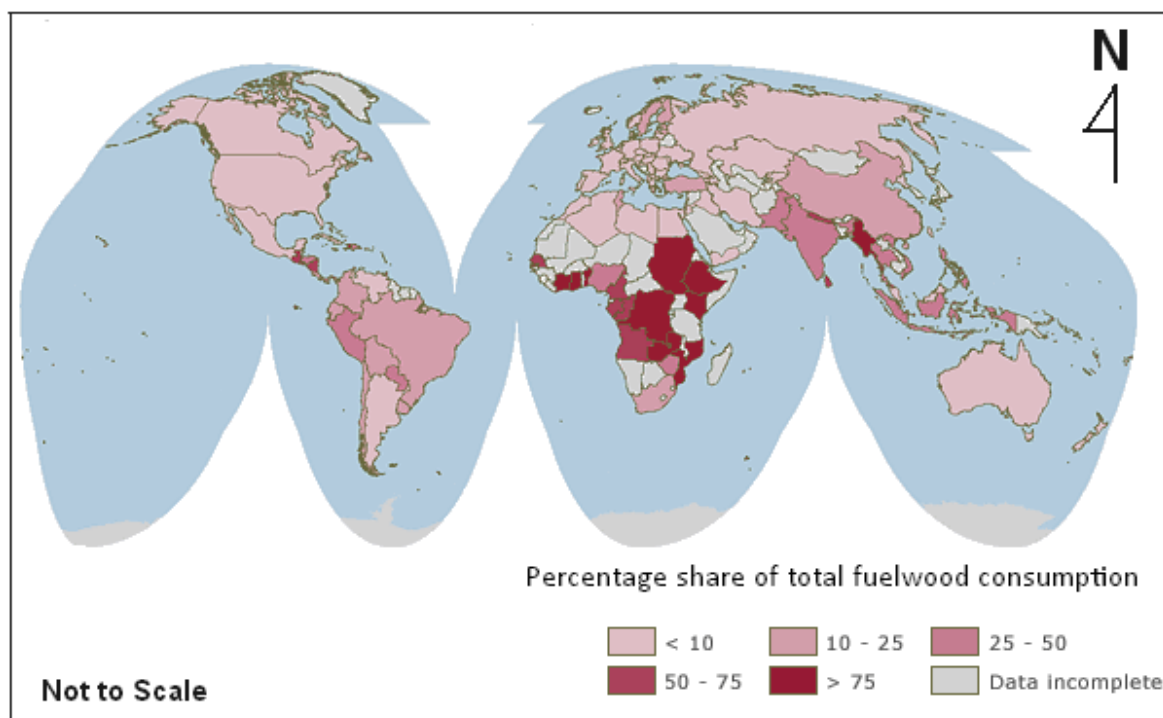


Figure 2.3: World Fuelwood Consumption

Source: International Energy Agency (IEA) (1996) cited in World Resources Institute (WRI) (2007).

and Ogunkunle and Oladele 2004 found that fuelwood consumption in the north and south western parts (the Ibadan area in Oyo state) of Nigeria far exceeds sustainable production, and the deficit is only made up from areas of surplus (pockets of localised vegetation in the other parts of the country- see chapter 9), which adds to the cost of the wood (Adeoti et al., 2001; see section 2.3.4 also).

Although consumption of fuelwood differs greatly even in the same region in a particular country (Eckholm et al., 1984), availability plays a vital role in determining the consumption pattern of fuelwood (Mlambo et al., 2003). Eckholm et al. indicated that in different countries, places with less fuelwood tend to use less than 500kg per head every year, while places with surplus use as much as 2000kg per head every year. Cline-Cole et al. (1987) put the annual consumption rate of fuelwood per person at 360 kg in Kano, Northern Nigeria, in a survey they conducted in the early 1980s. A different study conducted by Kersten et al. (1998) at Ile-Ife, in the southern part of Nigeria fifteen years later found that every person used 515 kg of fuelwood per annum on average. These two results indicate that Nigeria falls below the consumption level for fuelwood in surplus areas suggested by Eckholm et al. (1984). The two results also indicate that the northern part of the country has lower average consumption than the southern part. This is further illustrated in figure 2.4.

FAO (2003) showed that apart from the southern part of Nigeria where the high forest is found (see chapter 1: 1.3), there is no other region in the country that is self sufficient in the supply of fuelwood (figure 2.4). It is unclear how the increasing demand for fuelwood in the northern part of Nigeria (Guinea and Sudan Savanna) (Hyman, 1993; 1994) is to be met. While the Savannah area is large (refer to figure 1.1 in chapter 1), its fuelwood production is declining compared to that of the high forest zone. This could be attributed to its increasing demand for fuelwood as a result of its population increase (refer to table 1.1 in chapter 1) and the conversion of woodlands into farmland (land use change) (PBR, 2009 & FAO, 2010a).

However, if fuelwood supply in the northern part of Nigeria is shrinking as portrayed in figure 2.4, then what is the current and future outlook fuelwood in the region and the country at large? This question needs to be answered if the country is to avoid running out of the common man's basic energy source (FAO, 2011a).

2.3.3. Fuelwood Demand

Fuelwood was the very first source of energy for mankind and it remains the most important single source of renewable energy, providing over 9% of the global total primary energy supply today, making it as important as all other renewable energy sources (hydro, geothermal, wastes, biogas, solar and liquid biofuels) (FAO, 2011a & FAO, 2011b). In Nigeria, as depicted in figure 2.4, the demand for fuelwood is higher because more than 80% of households use fuelwood for their cooking, making it the most used form of cooking energy (Sambo, 2008a). The over-dependence on fuelwood in the country has been attributed to its availability and affordability compared to the other sources of energy (see section 2.5). From the perspective of the consumer, the availability and affordability of the energy source matters as well as the type of energy (Sambo, 2008a).

2.3.4. Fuelwood Procurement

Fuelwood procurement involves the process of selecting, chopping, gathering and transporting fuelwood (Williams, 1983). This definition identifies the complex activities involved in sourcing fuelwood for domestic usage, which was in the past considered to be solely the task of women in Africa (Williams, 1983; Hyman, 1983; McClintock, 1987 &

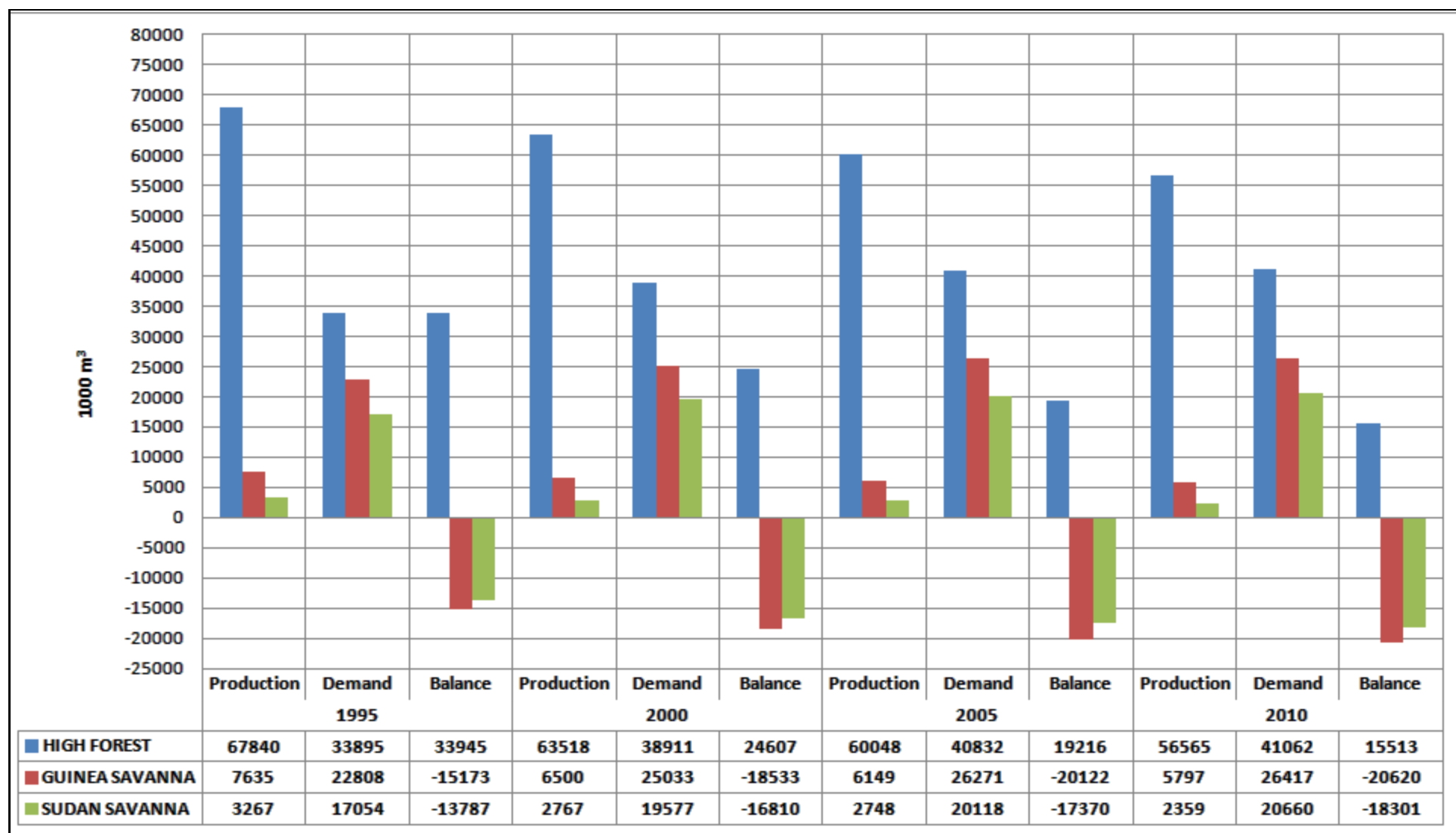


Figure 2.4: Comparison of Ecological Regions Production and Demand of Fuelwood in Nigeria (1000m³)

Source: Data adapted from Forestry Management Evaluation and Coordinating Unit (FORMECU) (1996).

Brouwer et al. (1997). For example Williams' research on the social organisation of fuelwood procurement and use in Africa, highlighted that women are the dominant sex in executing the task of collecting and using fuelwood. His findings also showed that women collect the fuelwood from short distances and in small quantities as a daily routine.

However, with the recent change in the state of fuelwood (shortage, distance to collection centres and marketing as discussed in section 2.4), there is now a shift in the paradigm that women were the primary collectors of fuelwood in Africa (Cooke et al., 2008). In addition, the new fuelwood situation highlighted in the preceding sections presents some challenges that have resulted to the active participation of men in the collection process. Men now engaged in long distance travel to procure fuelwood as a means of earning money (Christensen et al., 2009), using tools such as saws for cutting down the trees, and trucks to transport the wood (McClintock, 1987; Cline-Cole, 1987 & Christensen et al., 2009). This lead to a much faster deforestation rate than the use of family labour to procure the fuelwood (refer to section 2.3.1). While recognising the fact that the use of sophisticated tools and vehicles would expedite the process of cutting and transporting tree logs, little has been reported on the activities of commercial fuelwood collectors in terms of tools usage and the labour involved. It is therefore very important to ascertain the level of usage of these tools and measure the extent of environmental degradation caused as a result of using them, especially in Northern Nigeria, which has already been declared unsustainable in terms of fuelwood production (FAO, 2003).

2.3.5. Labour and Tools use

Although Palmer and Macgregor (2009) have reiterated the significance of family labour in reducing the cost of fuelwood in the family budget, Brouwer et al. (1997) highlighted that the farther the distance of fuelwood collection centres from the households, the higher the chances of these households switching to either the use of lower quality wood that is normally light and fast burning, which can be obtained from closer areas, or the purchase of the more expensive fuelwood obtained from a distance. Regretfully, both the two options are socio-economically stressful to households. An example is the case of Botswana, which experienced a shortage of fuelwood that resulted in more people spending the majority of their time in fetching fuelwood (Jelwic & Van Vegt, 1981).

Amacher et al. (1994), in a survey they conducted in Nepal, found that there was a huge contrast in the budget expenditure between households that met their demand for fuelwood using family labour and those that relied on the commercial fuelwood market for their supply. A similar situation was also reported by Palmer and Macgregor (2009), who examined the implications of commercial fuelwood participation among households in Namibia. They found that market participants (those that purchase their fuelwood) were more aware of price changes than non-participants (those that fetch their fuelwood using family labour). The survey results in Namibia and Nepal also revealed an almost parallel position in terms of money spent on the purchase of fuelwood among the households. Palmer and Macgregor also found that the Namibians tended to reduce their consumption rates instead of increasing the number of individuals involved in fuelwood collection as this was the most efficient way of dealing with the scarcity situation in the most cost effective manner.

2.4. The Role of Fuelwood Commercialisation on the Socio-Economic Activities of the People.

Fuelwood prices differ in the same way that consumption of fuelwood differs noticeably among households even within the same region of a particular country (Hyman, 1983; Leach, 1987; Chomitz & Griffiths, 2001 & Christensen et al., 2009). There are also no standard prices for fuelwood in the majority of the DC. For example, a survey conducted among 200 fuelwood merchants in Bangladesh showed that there was a huge difference in the price of fuelwood ranging between ten and one hundred percent (Leach, 1987). Fuelwood merchants determine the price and the consumer has no choice because of the scarcity situation, except to pay what is demanded (Shackleton et al., 2006). Implementation of policies in the DC to regulate fuelwood prices is therefore not a viable approach (see section 2.5.1 & chapter 9). The greatest impact of price fluctuations is felt by the poor households, who are among the major consumers of fuelwood in the DC (Perez-Verdin et al., 2009 & San et al., 2012). It is therefore not surprising that the impact of the commercialization of fuelwood on poorer households was described by Hegan et al. (2003) using the concept of 'the tragedy of the commons' (Hardin, 1968), because it is a localised market where the vendors can easily manipulate the price, since there is no formal regulating body to check their excesses.

For example, in a survey conducted by Hyman (1983) of fuelwood sellers and commercial charcoal makers in the province of Ilocos Norte in the Philippines, the fuelwood market was found to be a dispersed small-scale industry, where the majority vendors only participated seasonally or as a part time job. Hyman (1983) and Shackleton et al. (2006) also confirm that fuelwood is sold in many non-standard units of measurement and retail prices vary with location, volume of sale, responsibility for delivery and special relationships between the seller and buyer². In addition, Christensen et al. (2009) argued that the future evolution of the fuelwood market is unpredictable and it will most likely be influenced by infrastructural changes like good road networks. They therefore stressed the need for future policy intervention to save poor families from the fuelwood vendors' excesses by moderating the prices of fuelwood as happens in other energy sectors. Research conducted by Shackleton et al. (2006) in South Africa, where there is already a good road network system, showed that fuelwood is already an organised market system and the retailers earn meaningful income and can even create jobs for the unemployed. Shackleton et al.'s findings therefore indicate the viability of commercial fuelwood vending in providing income and job opportunities to poor households by creating more jobs.

Cuthbert and Dufournaud (1998) examined the consumption of fuelwood in some selected countries of Sub-Saharan Africa (SSA) from 1970 to 1990 and were able to determine the impact of income and price on fuelwood demand. Their results indicated that fuelwood would continue to remain a superior good for trade because of its situation (scarcity and demand) in the DC. Despite efforts to alleviate the problems caused by over-dependence on fuelwood in many DC (Shackleton et al., 2006), little has been achieved in terms of significant outcomes. As an example, Shackleton et al. states that most households in many parts of South Africa consume up to 1,200 kilograms of fuelwood per annum despite the availability of modern fuels and the state subsidization of electricity³.

² This latter marketing strategy was earlier reported in Northern Nigeria as a prerequisite for trading in the vegetable market in Jos (Porter et al., 2003 & Lyon & Porter, 2009).

³ Note that the situation of fuel subsidy in Nigeria is different from other DC because of the allegation of wide spread corruption (see section 2.5.3), which is part of the reasons why Maconachie et al. (2009) reported that households are descending the energy ladder in Northern Nigeria due to the shortage of fossil fuel supply (see discussion in chapters 6, 8 & 10).

2.4.1. Seasonal Variation and Prices of Fuelwood

There is a wide acceptance now that the structural systems of commercial fuelwood supply in most DC are not fully documented (McCrary et al., 2005). McCrary et al., examined the movement of fuelwood to the major markets of Masaya in Nicaragua, and reported that there was a high dependency on the natural forest to maintain the supply of fuelwood. There was also a disparity in the demand pattern of fuelwood in the rainy and dry season, with the latter season dominating the activity of fuelwood trading. Similar findings have been reported by some researchers both recently and in the past. Some of these findings are highlighted below.

McCrary et al. (2005) uses the figures of fuelwood traded at the peak of two different seasons in Masaya Nicaragua to determine the season that dominates fuelwood activity. They put the figures of fuelwood sold by vendors at 63,648 kg in a 5 day period in the dry season, while rainy season figures only accounted for 12,921 kg in a 5 day period. The two contrasting figures suggest that the activities of fuelwood are greater in the dry season than rainy season. A similar dry season demand pattern was earlier observed in Nigeria where reports indicated that there was a high demand for fuelwood in Northern Nigeria during the Harmattan season (dry winter period) (Polly, 1967 cited in Williams, 1983; Cline-Cole et al., 1987 & Alabe, 1996). A survey conducted in the rural mountainous region of Nepal by Christensen et al. (2009 p. 525) equally confirmed that fuelwood collection was observed to be very high in the dry winter season when the wood is relatively “dry and light”. Kumar and Sharma (2009) also show that the winter period dominates in terms of fuelwood demand and consumption across different seasons in Garhwal Himalaya, as might be expected.

Based on these findings, it is clear that the collection and selling of fuelwood are mostly conducted in the dry winter seasons in a majority of DC. However, these studies do not pursue the implications of these patterns of activities. For example, is hoarding an integral part of commercial fuelwood supply strategies among vendors to meet the demand of the rainy season, and would such hoarding have any direct consequences for households in monetary terms? Questions such as these have not been considered in previous work.

2.5. Fuelwood Versus other Energy Types in Nigeria

Nigeria has already shown a tendency towards excessive total fuelwood consumption (see tables; 2.1 above & 2.3 below), which according to Sambo (2008a) is due to population growth, low technical efficiency of the traditional cooking style and the lack of adoption of other sustainable cooking methodologies. While Sambo's (2008a) claims cannot be denied as part of the overall problem of fuelwood in Nigeria, one key factor he does not consider is the unreliability in the supply of alternatives to fuelwood in the country (see sections 2.5.1-2.5.3).

From table 2.3, Nigeria has estimated forest and woodland reserves of 11 million hectares and produces about 0.110 million tonnes of fuelwood per day. While Nigeria's forest area as a percentage of its total land mass is less than 10% (FAO, 2010a), the fuelwood utilisation in the country (0.120 million tonnes/day) surpasses its production, making it the only energy source in the country where utilisation surpasses production (Sambo, 2009). This is potentially catastrophic given that the country has been experiencing problems with its forest management (FAO, 2003), and most areas in the north have been declared unsustainable in terms of fuelwood production (FORMECU, 1996).

Also with the outcome of the 2005 UNDP MDGs report on the DC's energy situation, which stressed the need to reduce the high dependence on fuelwood, the future of Nigerian forests is not bright. The 2005 UNDP report on MDGs indicates that the majority of the countries participating in the MDGs project (including Nigeria) take little notice of the energy requirements of poor people, by only treating energy development within the context of large-scale infrastructure projects, without taking on board the traditional sources of energy in their policy decisions. The continued lack of commitment shown by most of the countries participating in the MDG's programme, to address the problem of energy deprivation is reflected in the energy poverty seen today in many countries (Florini & Sovacool, 2009; BBC Hausa, 2011a; Cherp et al., 2011 & Scott, 2012). At present, more than 2.4 billion people worldwide rely on traditional biomass as their primary source of energy and more than 1.6 billion people have no access to electricity (UNDP, 2005; Brew-Hammond & Kemausuor, 2009; FAO, 2010a, Kebede et al., 2010; Deichmann, 2011 & IEA, 2011). Based on these figures, it can be argued that a large segment of the world's population is deprived of improved energy services that can advance their economic growth and social equality. The UNDP (2005) report stressed the

Table 2.3: Energy Reserves, Production and Utilisation in Nigeria

S/No	Resource Type	Reserves (Natural Units)	Geographical Location	Production Level (Natural Units)	Utilization (Natural Units)
1.	Crude Oil	36.22 billion barrels	South-South South-East South-West	2.06 million barrels/day	445,000 barrels/day
2.	Natural Gas	187 trillion standard cubic feet (SCF)	South-South	7.1 Billion SCF/day	3.4 billion SCF/day
3.	Coal and lignite	2.734 billion tonnes	Spread Nationally	insignificant	insignificant
4.	Tar Sands	31 billion barrels of oil equivalent	South-West	insignificant	-
5.	Large Hydropower	11,250 MW	North-Central	1,938 MW (167.4 million MWh/day)	167.4 Million MWh/day
6.	Small Hydropower	3,500 MW	Spread Nationally	30 MW (2.6 million MWh/day)	2.6 million MWh/day
7.	Solar Radiation	3.5 - 7.0 kWh/m ² /day (485.1 million MWh/day using 0.1% Nigeria land area)	Spread Nationally	Excess of 240 kWp of solar PV or 0.01 million MWh/day	Excess of 0.01million MWph/day of solar PV
8.	Fuelwood	11 million hectares of forest and woodland	Spread Nationally	0.110 million tonnes/day	0.120 million tonnes/day
9.	Nuclear Element	Not yet quantified	North-East	insignificant	-

Sources: (i) Nigerian National Petroleum Corporation (NNPC) (2007), (ii) Renewable Energy Master plan (REMP) (2005) and (iii) Ministry of Mines and Steel Development (2008) all cited in Sambo (2009).

N.B: W= Watt; gives the power capacity; Wh= Watt-hour; gives the amount of energy produced or consumed; PV=Photovoltaic- The energy generated from the sun using solar panels; SCF= standard cubic feet; KW – kilowatt= 1000 MW; MW – Megawatt= 1000 KW; GW – Gigawatt= 1000 MW; TW – Terawatt= 1000 GW. **See box 2.2 for other sources of energy in the country.**

Box 2.2: Gas Turbines and Wind Resources for Electricity Generation in Nigeria

Although table 2.3 only provides the figures of hydropower and solar radiation as a means of electricity generation in the country, it should be noted that Thermal plants are also available. These Thermal plants (gas turbines) stations are powered by gas, and are well established in the southern part of Nigeria to boost the electricity generation in the country. The Thermal plants in the country have an installed capacity of about 2,730 MW, and are being utilised in the national grid (APS, 2010). On the other hand, wind energy in the country is not currently being utilised. However, the government has recently shown commitment to the utilisation of this resource in its effort to boost the country's electricity supply (Nigerian government has concluded a contract through its federal ministry of energy for a 10 MW wind farm in the northern state of Katsina - (Reve, 2010)). In addition, researchers have shown that Nigeria (at 25m Height) has the potential of producing an annual wind energy output of up to 120,078.90 kWh from Wind Turbines of 10m Blade Diameter and 790,548.39 kWh from Wind Turbines of 25m Blade Diameter, with good prospects in the north due to the open nature of the land (Agbetuyi et al., 2012 & Idris et al., 2012). Again, like other energy resources in the country, the Government has not shown enough commitment in harnessing its wind energy resource.

need for some development strategies in the procurement of energy in the participating countries that will address issues relating to fuel availability and rural energy development for easy access by the poor. The UN General Assembly's recent recommendation to designate an 'International Decade of Sustainable Energy for All' highlights the urgency and increasing momentum of this agenda (UN, 2012). The situation of energy access in Nigeria is discussed further below.

2.5.1. Fossil Fuel (Petroleum Products)

Fossil fuel resources are major economic assets worldwide (Sambo, 2005 & Sambo, 2008a). Petroleum resources, for example, have been the largest contributor to the Nigerian Federation accounts through export earnings and second largest contributor to the Gross Domestic Product (GDP) (Sambo, 2008a). Nigeria's oil reserves are estimated at about 36.22 billion barrels, while natural gas reserves are 187 trillion standard cubic feet (see table 2.3). The gas reserve is at least twice that of crude oil in energy terms (Nigerian National Petroleum Corporation (NNPC), 2010). NNPC is a corporate body responsible for organising the affairs of the Nigerian petroleum industry. In March, 1988 when the NNPC was reorganised by the government for the purpose of proper capitalisation and commercialisation, the Pipelines and Product Marketing Company (PPMC) was created (PPMC, 2010). PPMC is a subsidiary of NNPC tasked with the mandate of sourcing petroleum products and their distribution to all parts of the country at a uniform price (PPMC, 2010). The mode of PPMC's operation is quite simple, because in theory, PPMC receives crude oil from the NNPC Corporate Service Unit called National Petroleum

Investments Management Services (NAPIMS), which it then supplies to the NNPC local refineries in the country (3 in total, see figure 2.5 below) (PPMC, 2010). However, refined petroleum products were often imported into the country to supplement local production, due to the dilapidated state of the country's refineries (PPMC, 2010). The imported or locally refined petroleum products are then received by PPMC through import jetties or refinery depots and distributed by pumping the products through pipelines (5,120 km – total length) to the various depots and pump stations (23 depots and 8 pump stations, see figure 2.5 below) located all over the country, from where petroleum tankers transport the products to the filling stations (retail outlets). The PPMC's objectives (PPMC, 2010) include the following:

- 1) To provide excellent customer service by transporting crude oil to the refineries and moving refined petroleum products to the local markets efficiently at a low cost through a safe and well maintained network of pipelines and depots.
- 2) To profitably and efficiently market refined petroleum products in the domestic as well as export markets, especially the Economic Community of West African States (ECOWAS) sub-region.
- 3) To provide marine services and also maintain uninterrupted movement of refined petroleum products from the local refineries.

However, the task and objectives of the PPMC have not been fully achieved and instead the country constantly experiences irregularities in the supply of petroleum products (Ogbonnikan, 2012 & Okpi & Leke, 2012); shortages in the petroleum products pumped through the pipelines at the receiving destination (depots), a situation always attributed to sabotage and bunkering (Aroh et al., 2010); and tankers spilling petroleum products due to accidents on the major roads and cities in the country causing environmental issues and above all deaths etc. (Enogholase, 2011). These are some of the limitations of PPMC which are further discussed in sections 2.5.1.1 to 2.5.3 below.

Overall, fossil fuel remains the costliest energy type in Nigeria because of its high demand for both cooking, transportation, industries and lighting (Olise & Nria-Dappa, 2009). Olise and Nria-Dappa reported that the majority of poor households in African countries, including Nigeria, spend nearly 10-15 percent of their household income on the purchase of kerosene either for lighting (lamps) or for cooking (stoves). Olise and Nria-Dappa emphasised that the energy situation in Nigeria is more actually worse than has been

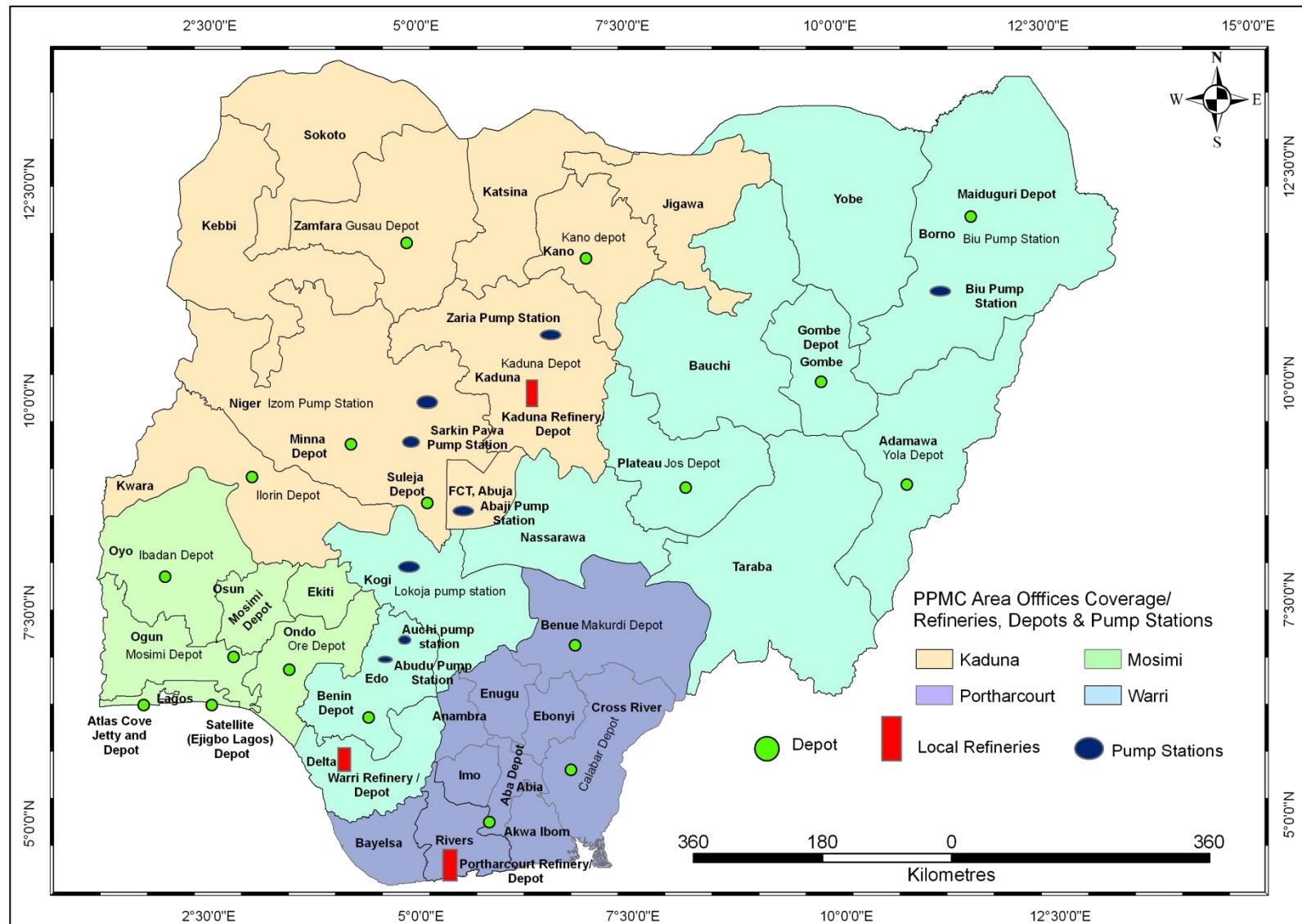


Figure 2.5: Geographical Distribution of Refineries, Petroleum Products Depots and Petroleum Products Pump Stations in Nigeria.

Source: Adapted from PPMC (2010).

revealed to the outside world. They presented their arguments on the basis of the household income ratio to their spending on energy and revealed that the poorest households earn about 1-2 US dollars per day and spend about 0.4 dollars per day on energy. This represents about 20-40 percent of the household's income spending on energy alone. Even though this figure seems to be high, the fact remains that the availability and acquisition of fossil fuel products in Nigeria is highly erratic due to the corruption that has become endemic in the NNPC (Ogbonnikan, 2012) - (see more discussion in sections 2.5.1.1 -2.5.1.3 and chapters 6 & 10).

2.5.1.1. Kerosene

Kerosene is the predominant energy source used in rural areas for lighting, while in urban areas it is used as a fuel in specific types of cooking stove (Olise & Nria-Dappa, 2009). There is strong evidence, as indicated by Sambo (2008a), of the use of small quantities of kerosene in both rural and urban areas for easy initiation of fuelwood combustion. Although the use of kerosene for cooking in Nigeria has been widely accepted (NAN, 2013b), there are problems which limit its availability to households. The Sweet Crude monthly edition of the Vanguard newspaper in Nigeria (July, 2011a) confirmed some of the issues hampering the availability of kerosene and other fossil fuels in the country and attributed all of them to the attitude of the marketers. The headline article entitled "*fuel subsidy gulps 1.3 trillion Naira (\$ 8.38 billion) in 2010*" explained the defective role of the marketers in compromising the supply of the product to the public. Five market scenarios for Dual Purpose Kerosene (DPK) in Nigeria were described, as follows:

- 1) DPK is obtained at a subsidised price and sold as a Household Kerosene (HHK) at three times the price to consumers.
- 2) DPK is blended with diesel to increase the volume of this fuel before it is sold at a deregulated pump price to the consumers. Diesel is the only fossil fuel that was deregulated in the country prior to the fossil fuel subsidy withdrawal in January, 2012 (BBC Africa, 2012).
- 3) DPK that is meant to be delivered to the pump stations for household consumers is diverted and sold as aviation fuel.
- 4) DPK is smuggled across the border because of the subsidy in Nigeria and sold at a much higher rate in neighbouring countries.

5) DPK is illegally transported across the border and then presented back to the NNPC as imported cargo for the purposes of claiming subsidy from the government.

Further evidence of these problems was provided by the Nigeria Minister of Petroleum Mrs. Allison-Madueke. During her confirmation interview with the Senate she disclosed that there was insufficient supply of kerosene in the country, and this was one of the most challenging issues facing the government (Abubakar, 2011). She also identified the problems associated with hoarding of kerosene by the marketers, which seriously affect the availability and supply of the product in the country. Further to this, she maintained that kerosene pricing will remain an issue even when kerosene is made available in the country in large quantity, because the type of kerosene (DPK) used in the country has the same quality as aviation fuel, which some corrupt marketers buy at a cheaper rate and sell at higher prices as aviation fuel.

Another issue related to kerosene scarcity in Nigeria is the wide circulation of adulterated and low quality kerosene that is available on the black market, which has been blamed for several explosions that have resulted in severe injuries and deaths in the country. Enogholase (2011) quoted the National coordinator of the Accident Victims of Nigeria (SAVAN), Dr. Eddy Ehikhamanor, who blamed the incidences of kerosene explosions in Nigeria on the management of NNPC. He specifically insisted that until the NNPC takes the issue of delivery and supply of kerosene very seriously, more Nigerians will continue to die from kerosene explosions. The problem is linked to pipeline theft and vandalism according to Dr Ajuonuma, a spokesman of the NNPC:

“We wish to alert members of the public of the presence of adulterated kerosene in the market, especially in the Warri-Benin axis, as a result of the nefarious activities of pipeline vandals who attacked our Warri - Benin products pipeline and made away with kerosene mixed with Automotive Gas Oil (AGO) and Premium Motor Spirit (PMS). The vandals may bring the stolen product to the market for sale to unsuspecting members of the public. Such adulterated kerosene could cause explosions and fire accidents. The consequences of past kerosene explosions are still very fresh in our mind.....; we cannot afford to have a repeat of such tragic incidents. We are therefore appealing to members of the public to be vigilant and desist from procuring kerosene from unauthorized dealers and outlets so as to avoid getting the adulterated products into their homes” (NNPC, 2013).

2.5.1.2. Gas

Given Nigeria's large gas deposits (table 2.3 above), the country's natural gas should have been used in such a way that households can benefit from its abundance. Instead, almost all of it is either traded for export revenue or used in the industrial sectors (Nigerian Gas Company Limited (NGC), 2011a), leaving the country's urban households to rely on the bottled gas cylinders that are unreliable in terms of supply, for their cooking needs (NAN, 2013b). The NGC was set up in 1988 as one of the 11 subsidiaries of the NNPC. It is mandated with the development of an efficient gas industry to fully serve Nigeria's energy and industrial sectors needs through an integrated gas pipeline network and also to export natural gas and its derivatives to the West African Sub-region (NGC, 2011b). Although the NGC has a clear mandate to supply more energy to the industrial sectors of the country, it is unfortunate that after twenty three years of its existence, it has only laid about 1,250 kilometres of pipelines serving mostly the industrial areas of the southern regions of the country (NGC, 2011a). NGC claim that the Oben-Ajaokuta-Geregu Gas Pipeline System will form the back-bone of the proposed Northern Pipeline System, which has not yet been built. NAN (2013b) quoted the Managing Director of Techno Oil, Mr Tony Onyeama, lamenting the low consumption level of cooking gas by Nigerians, who emphasised that *"the usage of cooking gas in Nigeria stands at 0.5kg per capita, compared to 3kg per capita in Ghana, 1.9kg in Cameroon, 5.5kg in South Africa and 44.4kg in Morocco"*.

Overall, no widespread evidence has been found of gas pipelines supplying houses in Nigeria. However, in a verbal communication with one of the retired NNPC managers (who remained anonymous), it was confirmed that there was a project proposal for gas pipeline supplies, especially in the southern part of the country, through the NNPC. The pilot project started and ended in the NNPC quarters in the Warri area of Delta state in the southern part of Nigeria, serving only the top NNPC management residential quarters. Although the use of bottled gas among households is restricted to the wealthy in urban areas (NAN, 2013b), the issues associated with the procurement of gas are similar to those of kerosene mentioned earlier, where the government and marketers are seen as the central source of problem concerning the procurement of fossil fuels in Nigeria. Another reason given for the failure to make fossil fuel available is that the government subsidy is not serving its intended purpose but rather assisting the marketers to become

even richer (Ogbonnikan, 2012 & Okonjo-Iwela, 2012). Section 2.5.3 examines fuel subsidies in Nigeria.

2.5.1.3. Distribution of Petroleum Products in Nigeria

In addition to the problems in procurement of fossil fuels, unreliable supply and distribution of all petroleum products also remains a significant challenge (Alohan, 2011a). In consequence poor people have to depend on expensive black market sources for their needs, and the government has failed to address the matter. The persistent scarcity is attributed to the close relationship that exists between the government and the marketers for their own benefit. This has a major implication for poor households' budgets. At present, the official price of kerosene (after subsidy) is 50 Nigerian Naira (£ 0.20 Pence) per litre, but it can hardly be found anywhere for that price and therefore people are forced to rely on the black market where it sells for about 300 percent of the official litre rate, depending on the state (Sango, 2011) (see table 2.4 for the history of fossil fuel prices in Nigeria).

Other problems associated with the unreliability of petroleum products supply in Nigeria are the issues of illegal oil bunkering (theft of crude oil) and smuggling of both the crude and refined petroleum products (Nwafor et al., 2006). Garuba (2010 p. 11) pointed out that illegal oil bunkering and smuggling became very popular in Nigeria during the Babangida regime (1986-1993) but have now reached their peaks. Political instability in Nigeria over the years provided a favourable operating environment for oil bunkering to thrive (Asuni, 2009). However, Garuba, (2010) shows that the initial opportunity for the practice to develop was favoured by the domestic subsidy of Nigerian petroleum products and devaluation of the Nigeria Naira in the mid 1980s. During this time legally lifted products were diverted to more profitable markets across the porous borders of the Communaute Financiere Africaine (CFA) Franc countries surrounding Nigeria (i.e. Niger, Chad, Republic of Benin and Cameroun) (Nwafor et al., 2006). These operations were mainly facilitated by government officials, with the assistance and cooperation of some oil company workers and their cronies (marketers) (Garuba, 2010). Although the operational structure of the business is not well articulated in research studies (Asuni, 2009) because of the secrecy surrounding the business, Garuba reported that studies in illegal oil bunkering and smuggling put the loss at around \$7.7million daily to the Nigerian government's income. The report of the Nuhu Ribadu-led Petroleum Revenue Special

Task Force submitted to the FG in November 2011 further confirmed the irregularities in the petroleum sector of the country (Leadership Editorial, 2012).

Table 2.4: An Overview of Fossil Fuel Prices in Nigeria (1973-2012)

	Premium motor Spirit (PMS- petrol)	HHK	LPG (Cooking gas)
Year	Naira per litre	Naira per litre	Naira per 12.5kg
1973–78	0.10	0.08	31.2
1979–85	0.15	0.11	32.3
1986–89	0.40	0.11	40.0
1990	0.51	0.15	40.0
1991–92	0.60	0.40	80.0
1993	3.25	2.75	200.0
1994–97	11.00	6.00	200.0
1998–99	20.00	17.00	450.0
2000–01	22.00	17.00	1000.0
2002	26.00	24.00	1200.0
2003	40.00	38.00	1500.0
2004	43.00	50.00	1700.0
2007	65	50.00	N2, 500
2012	97	50.00	N3,500

Sources: 1. Nigerian National Petroleum Corporation; and 2. Central Bank of Nigeria (CBN): Annual Reports and Statements of Accounts, various issues; Adapted from Adelekan and Jerome (2006 p.102); and 3. Okpi and Leke (2012). (Note: 250 Naira = £1)

Another issue associated with petroleum product supply in Nigeria is the frequent union strike actions against the government (Nuhu-Koko, 2007). The key reason behind the strike actions is mostly disagreements between the government and the Nigeria Labour Congress (NLC) or the Trade Union Congress (TUC) over changes in policy that affect the people directly (like fuel price increases, wage increases or the dismissal of some workers) (Agbo, 2012 & Ogunmola, 2012). Lack of insecurity is also a sensitive issue that is leading to strike action against the government; specifically, issues relating to attacks by the police and military officers, especially on tanker drivers whose organisation (the Petroleum Tanker Drivers Association (PTD)) intervenes by calling for a general strike action against the government (Agbo, 2012). The number of strike actions against the government in the past by the PTD, which is also a branch of the National Union of Petroleum and Natural Gas Workers (NUPENG) is large. However, most of the strikes by the PTD were not necessarily on issues relating to the PTD directly or its mother union NUPENG but rather a problem of the NLC of which NUPENG is a part (John, 2012). All the PTD's strike actions in the past specifically affect the supply of all petroleum products in the country, largely because they are the sole conveyors of such products from the depots, or Jetty tanks to the filling stations across the whole country (PPMC, 2010). As

such, whenever there is a strike action, the national supply is reduced, filling stations are under-supplied and soon become empty and consequently the whole country is affected (John, 2012 & NAN, 2012d). Other petroleum union strike actions that also affect the supply of petroleum include the Independent Petroleum Marketers Association of Nigeria (IPMAN) and the Depot and Petroleum Products Marketers Association of Nigeria (DAPMAN) (NAN, 2012e).

2. 5.2. Electricity

One of the effects of poor policy implementation is the erratic supply of electricity among the majority of households in SSA (Brew-Hammond & Kemausuor, 2009). With all their abundant energy resources, countries in the SSA are still struggling with meeting their electricity demand. In terms of households' access to electricity, IEA (2011) World Energy Outlook drew attention to the 1.3 billion people without access to electricity. In the SSA, only about 30% have access to electricity, making the region the lowest in the world in terms of its electrification rate (Brew-Hammond & Kemausuor, 2009). In Nigeria for example, most communities do not have access to electricity; and those that do cannot rely on the very poor supply from the country's electricity provider the Power Holding Company of Nigeria (PHCN) (Akarakiri, 1999, Sambo, 2008b & Olise & Nria-Dappa, 2009). This lack of access to efficient energy resources has had adverse impacts on the economic development of Nigeria (Olise & Nria-Dappa, 2009), where most of the industries are running on diesel generators with an added cost to their outputs (Sambo, 2008b). Electricity, being the third energy type in Nigeria in terms of significance in the household sector in the country (Sambo, 2008b), is mostly limited to states and local government headquarters and some towns, while the rural areas are served by the States' Rural Electricity Boards (Sambo, 2008a & Sambo, 2008b) with an even worse record in terms of supply.

A brief history of electricity generation in Nigeria summarised from the works of Akarakiri (1999) and Sambo (2008b) will help in understanding some of the complex issues involved. Electricity supply dates back to 1896 when it was first produced in Lagos by the colonial administrators (Sambo, 2008b). A central body known as the Electricity Corporation of Nigeria, now defunct, was later set up in 1950 to act as the central body to develop and supply electricity in the country (Akarakiri, 1999 & Sambo, 2008b). However, even at that time, other bodies like the Native Authorities, the Nigeria Electricity Supply

Company (NESCO) and the Niger Dams Authority (NDA) had licenses also to produce electricity in some locations in Nigeria (Sambo, 2008b). NESCO, for example, is a private company that still exists today in some areas of Plateau state in the northern part of Nigeria supplying a few towns and some industries in the state capital (Jos) with electricity with a high degree of reliability. While the electricity produced by NDA (now defunct) was sold to the Electricity Corporation of Nigeria for distribution and sales to consumers (Sambo, 2008b).

In 1972, the National Electricity Power Authority (NEPA) was set up to take over the responsibilities for generation and distribution of electricity in the country from all existing organisations (Akarakiri, 1999), and in 2005, the name NEPA was changed to PHCN. Despite the long existence of electricity projects in Nigeria, its development is considered to be very slow compared to the nation's demand (Sambo, 2008b). The major reason for this is the laxity of the past military governments in making any commitment to the development of the sector (Sambo, 2008b). Sambo (2008b) indicated that before 1999 (the end of military rule in Nigeria) the power sector did not witness any substantial investment in terms of infrastructural development and the existing ones were not properly maintained. For example, in 2001 when the then government showed a commitment towards electricity generation and engaged in a thorough investigation of the sector, electricity generation was discovered to have declined down from the installed capacity of about 5,600MW to an average of about 1,750MW, compared to the national demand at the time of 6,000MW. It was further discovered that only nineteen out of the seventy-nine installed generating units were functioning at that time (Sambo, 2008b).

Other problems of the PHCN (related to social issues) that are considered to be responsible for the unannounced load shedding, prolonged and intermittent outages which most consumers of electricity in Nigeria have had to contend with over the years, can be summarised from the Nigerian National Bureau of Statistics, (NBS) (2010) as follows: a poorly-motivated workforce, vandalism and the theft of cables and other vital equipment, accidental destruction of distribution lines, illegal connections that resulted in over-loading of distribution lines, and non-payment of bills by the consumers. The combination of these problems has resulted in the present deplorable state of electrical power supply in the country (Otuchikere, 2013). Akarakiri (1999) reported that at full design capacity, the electric power stations in Nigeria should have been capable of

producing about twice the electricity requirements of Nigeria plus those of neighbouring Niger, the Benin Republic and Chad.

Sambo (2008b, p. 33) predicted the future of Nigerian Electricity demand using GDP projections and found that at a 13% GDP growth rate, Nigerian demand for electricity will rise from 5,746MW in 2005 to 297,900MW by 2030. The difference in the figures indicated that an increment of 11,686MW is required every year from 2005 to 2030 to meet the demand. The corresponding cumulative investment (investment and operations) cost for the 25-years period is estimated at about US\$ 484.62 billion, which means an investment of about US\$ 19.38 billion every year within the period (Sambo, 2008b). Although the model accounts for other energy needs in the country, it can be argued that it was based on an over-estimate of the real GDP rate of increase in Nigeria, which was only estimated at about 7.86 percent in the third quarter of 2010 (NBS, 2011). At a more realistic 7% GDP growth rate, Sambo (2008b) predicted the demand for electricity would rise from 5,746MW in 2005 to 119,200MW by 2030. This would require an investment of about of US\$ 6.46 billion every year within the period, which will only be achievable if the economic opportunities in the country are improved to curtail some of the social and other energy issues in the country highlighted earlier, and corruption is reduced (Agba et al., 2012a). Brew-Hammond and Kemausuor (2009) warned that the government needs to develop other energy sectors while addressing the electricity situation in the country, otherwise the dream of meeting the demand of electricity for all will remain an illusion rather than reality, even if the money were available to fund the project.

However, the FG in 2012 have privatised the PHCN generation and distribution companies, and arrangements have been finalised to hand over to the core investors in the second quarter of 2013 (Anthony-Uko, 2013 & NAN, 2013a), Nigerians are desperately hoping to see meaningful improvements in their electricity supply as a result.

2.5.3. Overview of Energy Subsidies in Nigeria

Nwafor et al. (2006 p. 3) examined two types of subsidies, the explicit and the implicit. Explicit subsidy is the difference between production cost and selling price. Implicit subsidy is the type of subsidy that is observed in the exploitation of wasting assets such as crude oil. It refers to the difference between the opportunity cost of a wasting asset and the present selling price. Nigeria has both types of subsidy which the government

withdrew in January, 2012 (BBC Africa, 2012). Governments use their oil endowments through subsidy as a social means that is intended to benefit the large majority of the poor in their society as well as to promote industrial production (Birol et al., 1995 & Nwafor et al., 2006). Although the Nigerian government's intention was good regarding oil subsidy, the subsidy was abused by certain individuals (Dada, 2012; Ogbonnikan, 2012 & Okonjo-Iwela, 2012), which is why it was eventually removed (partially). Prior to the subsidy withdrawal, the (present) Nigerian minister of Petroleum Mrs. Allison-Madueke argued that *"the subsidy is not getting to the masses it is created to take care of...; it is the retailers that are benefitting from it"* (Abubakar, 2011 & Sweet Crude, 2011a). Before her comments, Nigerian state governors had earlier advocated the total removal of oil subsidy in the country so that they could benefit from the money thus saved and be able to pay the newly introduced minimum wage of 18,000 Naira per month (£72). This would avert strike action organised by the NLC, which represents less than 20 percent of the country's population (BBC Hausa, 2011b & Olanrewaju, 2011). The move by the state governors was, however, opposed by widespread condemnation from the general population (Olanrewaju, 2011). However, despite this condemnation, the government suddenly announced the withdrawal of its fuel subsidy on 1st January, 2012, which resulted in a sharp petrol price increase from 65 Naira (about £0.26) to 140 Naira (about £0.60) (BBC Africa, 2012). After the announcement, there was a mass protest across the country that lasted for 16 days (BBC Africa, 2012). It was only after the leadership of the National Assembly intervened that the government partially backtracked on 16th January, 2012, by approving the reduction of the pump price of petrol to 97 Naira (about £0.40) per litre.

The call for the removal of the oil subsidy among oil producing nations, especially DC, is not new. Birol et al. (1995) indicated that the move started in the late 1970s and reached its peak in the 1980s. Birol et al., who support subsidy removal, argued that the oil exporting countries of the DC have a high level of subsidy and low efficiency of energy use, resulting in the waste of resources needed for their development. Birol et al. maintained that for the oil exporting DC to advance, they need to allow their energy pricing to reflect the opportunity costs, to enhance economic growth. They summarised the impacts of oil subsidies on economic growth, as follows (Birol et al., 1995, p. 210):

1. Subsidies for consumers bring about excessive domestic demand, which leads to lower export that consequently decreases the foreign exchange revenues which would have funded development activities.
2. Subsidies for producers bring about excessive supply, leading to a rapid depletion of the resources that provide the main source of earnings.
3. Subsidies do not necessarily reach the target poorer segment of the population. Rather, most of the beneficiaries are in the higher income groups of the society that can afford the unsubsidised oil.

Although Birol et al.'s arguments were quite strong, given the present poor economic situation of Nigeria (FAO, 2010a), their arguments can be criticised for being unfair, because they were based on assumptions that did not reflect the situation of the Nigerian oil crisis and the economic hardship of the people (Nwafor et al., 2006 & Bisalla & Muhammad, 2012). Nwafor et al. (2006) have shown that in Nigeria, the increase in the price of petroleum products resulted in the increase in the prices of all other goods and services. They therefore concluded that subsidy removal would increase national poverty, unless the money saved was used in a way that would bring about changes for the household economy.

Electricity is being subsidised in Nigeria in a similar way to fossil fuels. The government has recently announced it will cut down its funding of this subsidy, by deregulating the sector as part of its commitment to meeting the country's electricity demand (NBS, 2010, & Sweet Crude, 2011b). Sweet Crude (2011b) reported that the FG has released the sum of 177 billion Naira (about £708 million), for subsidies to ensure an orderly transition from subsidy to market determined prices of electricity. As part of the subsidy removal process, the Nigerian Electricity Regulation Commission's (NERC) chairman, Dr. Sam Amadi, announced an increase in the electricity tariff from 1st July, 2011, from 8.50 Naira (3.4 Pence) to 10.00 Naira (4 Pence) per unit (Alohan, 2011c & Sweet Crude, 2011b). This announcement did not spark any civil unrest in the country like that for oil mentioned earlier, because most of the people had previously given up relying on the country's electricity supply.

Even though there are beneficial aspects of both deregulation and subsidy, Nigeria's current situation only favours the subsidy. This argument can be supported by Sango's (2010, p. 18) claim that *"the government expectations that the removal of subsidy will*

solve the situation of fuel scarcity in the nation is wrong”, because when one looks at the situation of diesel supply that was deregulated some years ago, this fuel still faces similar problems to other petroleum products in terms of supply and availability in the country as discussed above. Unsurprisingly, therefore, the current petroleum scarcity in the country to date has not changed from its previous situation prior to the subsidy withdrawal (Agba et al., 2012b).

2.5.4. Transition from Fuelwood to Fossil Fuel

The 1970s increase in the world prices of fossil fuel (figure 2.6), (Nash & Luttrell, 2006 & British Petroleum (BP), 2009) was another factor that turned the attention of researchers to the study of the fuelwood consumption pattern in the world. However, what is lacking empirically, are studies that show the direct relationship between fuelwood consumption and fossil fuel prices.

Nevertheless, there is research evidence that indicates that the money spent on the purchase of fuelwood by poor households in the DC is large (Leach, 1987& Adeoti et al., 2001), mainly as a result of the unreliability in the supply of fossil fuels that are meant to substitute for fuelwood in most parts of the DC (Leach, 1987).

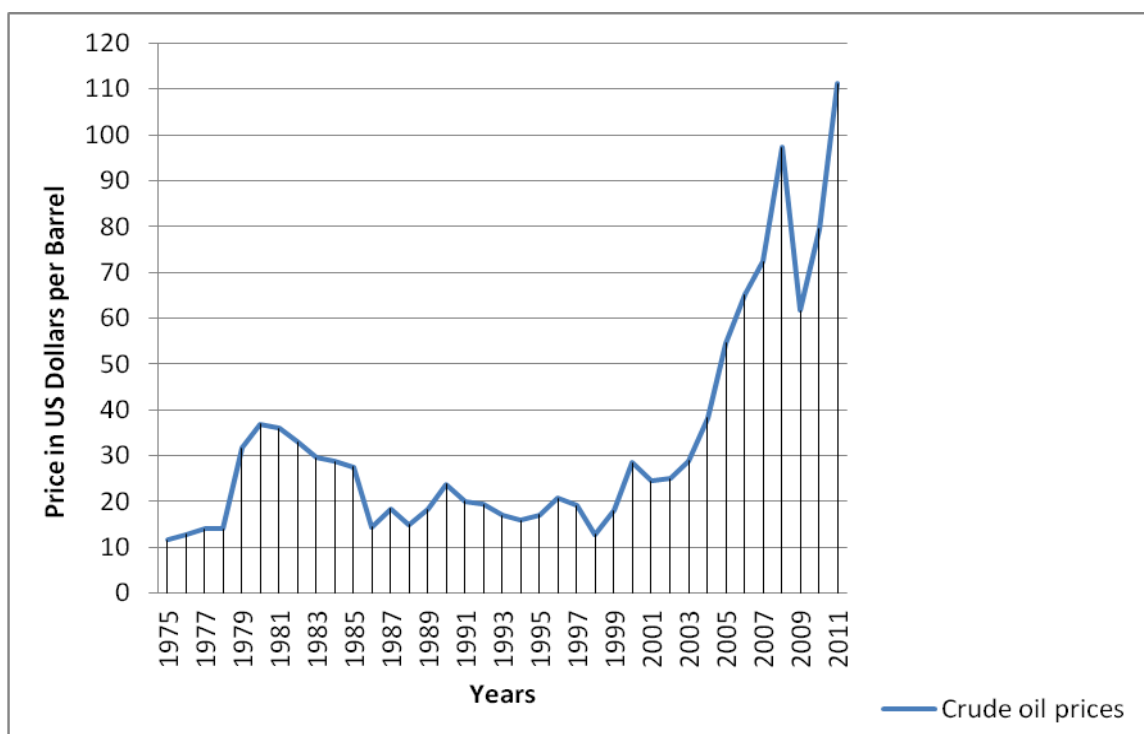


Figure 2.6: Annual Price of Crude Oil

Source: British Petroleum (BP) (2012).

In recent years, there has been an increasing concern over rising fuelwood prices, supply shortfalls and the environmental impacts of fuelwood use (Hyman, 1994), which have fed a growing interest in switching to the use of other forms of energy. One of the top priorities is switching over to the use of petroleum products and other forms of renewable energy. It is obvious that if the supply and price of petroleum products is reliable in the DC, many people may be willing to switch over to their use. For example; most DC have already adopted policies that will encourage people to use more fossil fuel for domestic purposes, but the outcome has not been encouraging (Nash & Luttrell, 2006). Leach (1987) proposed in a study entitled, 'Energy and the urban poor' the idea of implementing a policy that would increase the price of fuelwood to encourage people to use fossil fuels.

As indicated earlier in Nigeria the government has adopted the policy of subsidising petroleum fuels (Adeoti et al., 2001) in terms of distribution and pricing in order to achieve a uniform price throughout the country (Ehinomen & Adeleke, 2012, p.236). Despite all the encouragement and subsidies, no consistency has ever been achieved in fossil fuel supply (Adeoti et al., 2001 & Ehinomen & Adeleke, 2012). In the light of this, switching to the use of fossil fuels (gas and kerosene) in Nigeria has proved to be very slow, hence the reason for the dependence on the use of fuelwood by households (Hyman, 1994 & Hiemstra-van der Horst & Hovorka, 2009).

However, the situation is not the same for all the DC, China for example, which accounted for the world's highest energy consumption in 2008 (BP, 2009), is doing well with its energy transition in rural areas. Jiang and O'Neill (2004) noted that although the Chinese transition programme from the use of fuelwood to other fossil fuel is very slow, the future is bright because of the wide acceptance of the programme by the people and consistency in the supply of fossil fuels.

It is worth emphasising here that the problem of petroleum products in the DC certainly lies with the supply of such a commodity. As BP Chief Executive Tony Hayward stated in the 2009 'statistical review of world energy', "*the production of petroleum products far exceeds the consumption*". Given this fact, it is still not always clear why the supply of petroleum products is unreliable and unstable in most parts of the DC. In the case of Nigeria, the situation is fairly understandable, based on what has been said earlier and the political and socio-economic problems of the country over the last decade, which

have seriously affected the regulatory bodies in charge of the supply, distribution and marketing of petroleum products at all levels (Bisalla & Muhammad, 2012). However, the existing literature does not explain whether the existing supply strategy for fossil fuels on regional basis has any effect on varying consumption patterns of fuelwood in Nigeria.

2.6. Remote Sensing (RS) Studies of Vegetation Change

There is the need for frequent study of land cover change in the DC using Remote Sensing (RS) due to their continually changing vegetation patterns as a result of deforestation (DC Nelson & Geoghegan, 2002 & FAO, 2010a). Through such studies, priority locations that require urgent intervention can be identified and effectively managed. For example, Helldén and Tottrup (2008) use the National Oceanic Atmospheric Administration's (NOAA) Normalized Difference Vegetation Index (NDVI) Global Inventory Modelling and Mapping Studies (GIMMS) data from July 1981 to December 2003 that were generated from Advanced Very High Resolution Radiometer (AVHRR) to show that the forest areas of most arid zones of the world are not decreasing, but rather increasing. Although the resolution of the sensor they used in their study is quite large and may not necessarily be optional for the study of forest change, especially at local level, their results yielded new findings at the regional level. For example, the southern Sahel regions, previously regarded as a fragile area in terms of land degradation (deforestation) have recorded an increase in vegetation cover over the period of twenty two years. However, whether this increase was the result of natural regeneration or re-afforestation programmes were not demonstrated (FAO, 2010a).

While the study of land cover is progressing in most DC, such studies in Nigeria are regarded as inconsistent and insufficient compared to the country's needs (Okude, 2006, cited in Ademiluyi et al., 2008). For example, the first comprehensive land cover and land use map of Nigeria, which constitutes the only national database of the country's forest environment using RS techniques, is the Nigerian Radar project (NIRAD). This project was conducted between 1976 and 1978 using a RADAR sensor (sideways-looking airborne radar) (Parry & Trevett, 1979). The project faced criticism after the submission of the report (Blair-Rains et al., 1979). These criticisms included the choice of sensor for the project, overlaps between land use and land cover classification and the scale (1:250,000) at which the final map was produced. The second most comprehensive land use/land cover inventory project conducted in Nigeria after the NIRAD project was carried out by

the FORMECU in 1996 (Ademiluyi et al., 2008). The task was accomplished using different sensors, such as AVHRR, Satellite Pour l'Observation de la Terre (SPOT), Landsat-Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+), European Remote Sensing Satellite 1 (ERS-1 RADAR), Japanese Earth Resources Satellite 1 (JERS-1 RADAR) and NOAA. The project faced similar criticisms to that of the NIRAD project. Therefore, the NIRAD project still remains the most comprehensive land cover inventory ever undertaken in Nigeria using RS.

2.7. Chapter Summary

From the literature reviewed, the status of the Nigerian forestry system and of supplies of fuelwood and other energy sources has been clarified. There is an ongoing debate on the use of the term deforestation, as a result of the numerous definitions of the term forest (more than 650 definitions, according to FAO). This study adopted the definition promoted by Forsyth, because it goes beyond the FAO's definition (which only considered a forest ecosystem with 10 percent tree canopy of 5 metres of height), by including other types of vegetation ecosystem (such as savanna vegetation ecosystem) in its description of deforestation. The record of deforestation in Nigeria reveals that the country is among the top five countries in the world with the largest net loss of forest area and the highest percentage annual deforestation rate since 1990.

Despite a high rate of deforestation and fuelwood consumption reported in Nigeria by FAO (2010a), vegetation change studies in Nigeria are insufficient, with the majority focussing on the high forest areas of the south, while the savanna areas in the north have been neglected despite the pressing need for research there. Even in the high forest areas, the majority of the information sources (land cover maps) are outdated, which presents a unique problem in terms of generating information due to the lack of contemporary land cover map updates.

Although there is now a consensus that the majority of families in the DC depend on the use of fuelwood, especially for cooking, such records is not well documented in Nigeria. Given the importance of fuelwood, and its position as the most influential factor in deforestation (FAO, 2010a), its use needs constant monitoring, particularly in the northern part of the country⁴. The pattern of fuelwood collection is also changing. The

⁴ Due to the nature of its vegetation and the declaration that the region is unsustainable in terms of its future fuelwood supply (FORMECU, 1996 & FAO, 2003; see section 2.3.2).

majority of researchers now disregard the earlier notion of the influence of family labour in the collection process as the main driver of deforestation in favour of the commercial fuelwood activities. However, little is known about the precise extent of vegetation areas being cleared as a result of fuelwood collection. This is examined in subsequent chapters. Also, little has been reported on the activities of commercial fuelwood collectors, in terms of tool usage and the labour involved, which is another area that this study investigates. Other issues to be considered include seasonal variations in the use and selling activities of fuelwood among vendors, and whether hoarding is an integral part of commercial fuelwood supply strategy.

The existing high level of dependence on the use of fuelwood among households and the pattern of the supply of other alternative energy sources in Nigeria has shown that the country is already experiencing a fuel poverty situation. According to Sambo (2008a) this is due to several factors ranging from population growth to the low technical efficiency of the traditional cooking style. However, one other key factor that is lacking from Sambo's analysis is the unreliability in the supply of alternatives to fuelwood in the country, which is linked to major allegations of corruption and irregularities from both the government and the marketers. This is further investigated in this study because of its potential importance to the use of fuelwood in the country.

From the foregoing it is obvious that there are complex issues surrounding energy provision in Nigeria that are yet to be fully understood. To unpack these issues requires a relatively localised study, as emphasised by Forsyth (2003), and the deployment of a multiple methodological approaches, whose results can be interpreted in conjunction with one another, in order to provide a fully contextualised understanding of the problems involved and suggest possible policy solutions. The use of multiple methodologies allows different aspects of the overall problem to be examined at different geographical scales. At the broader regional and national scales, in terms of the monitoring of vegetation change, an RS approach is the only feasible means of obtaining reliable data. The relationship between socio-economic characteristics of the population and fuel use, in contrast, require a census-based statistical approach to examine both the national situation and regional variations. To situate these broader findings in a more local context, a combination of participant observation and survey techniques is needed, despite the logistical issues (and indeed safety/ security issues) that may be encountered in the process. Past studies have used some of the methodologies, singly or in

combination. Examples include Jelwic and Van Vegtan (1981) who used observational techniques to study villages in Botswana, and Olsson (1985) who combined RS and interviews to examine fuelwood use in North Kordofan, Sudan. However, no previous study has utilised the full range of methodologies listed above to examine the fuelwood problem across all scales from the national to local level. The three methodological approaches (figure 2.7) adopted can be summarise as follows;

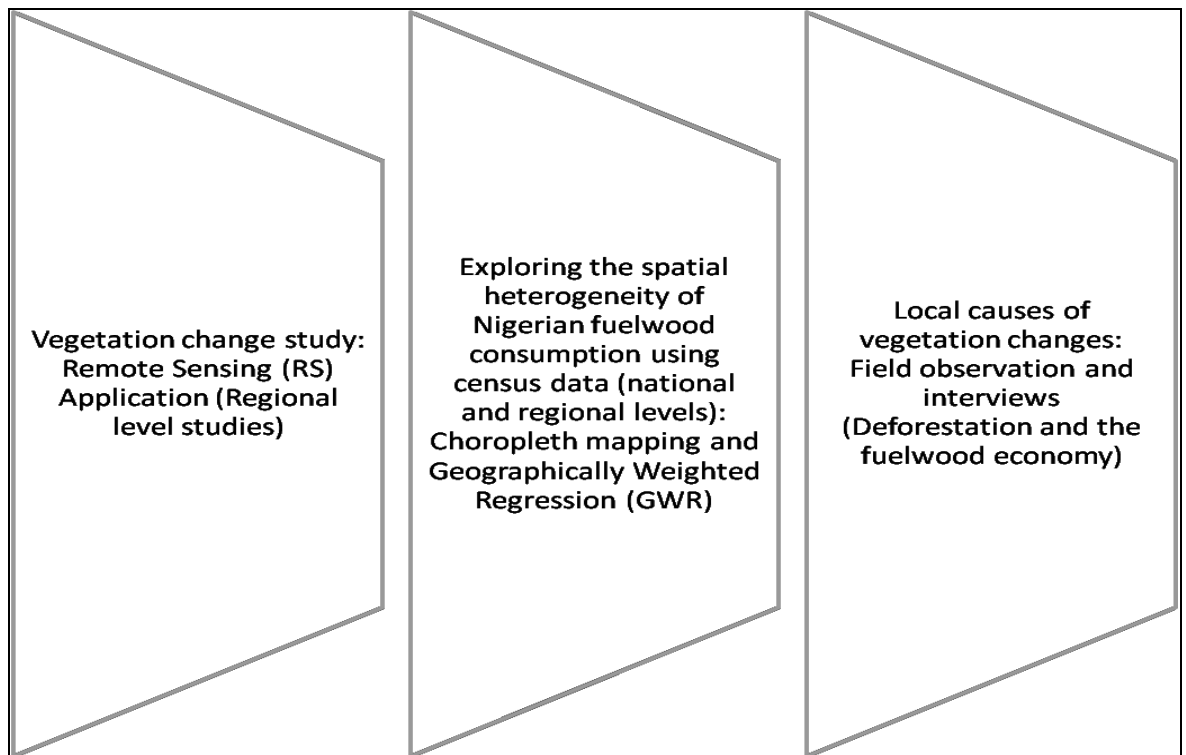


Figure 2.7: Multiple Methodologies Used

Chapter 3: Methodology (Remote Sensing Based Study)

3.1. Introduction

This chapter describes the methodological approach to the study of vegetation change patterns using Remote Sensing (RS) method. The first section of the chapter describes the need for frequent studies of vegetation change in the Developing Countries (DC) using RS. Sections 3.2.1 and 3.2.2 discuss the source, and type of RS imageries used. Section 3.2.3 discusses the procedures used in imagery processing and enhancement prior to analysis, while sections 3.2.4 to 3.2.6 shows the various stages of the RS modelling approach used.

3.2. Remote Sensing (RS) Application

The incorporation of RS in the study of forest change has improved the way information about the forest was extracted (Olsson, 1985). As such, RS application in the area of vegetation cover inventories have proven to be important in recent times (Chowdhury, 2006b & Ademiluyi et al., 2008), with most applications aiming at monitoring environmental performance (Innes & Koch, 1998). RS sensors such as Advanced Very High Resolution Radiometer (AVHRR), Satellite Pour l'Observation de la Terre (SPOT), Landsat-Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) and RADAR was used to monitor forest conditions in terms of land cover richness and vegetation clustering with great success in many parts of the world. Some of the qualities of RS as a means of extracting information as reported by Chowdhury (2006b) and Sader and Legaard (2008) are briefly highlighted below.

RS data can provide information on the spatial organization and structural elements of the landscape across a large area far greater than could be provided by ground assessment alone. In addition, the assessment of the structure and spatial organization of landscapes is much faster and geographically more accurate when analysed by RS rather than ground survey alone. Innes and Koch (1998) show that RS methods can effectively provide the necessary information on land cover characteristics across large areas. In this study, Landsat satellite imageries have been used to evaluate the characteristics of vegetation change in Potiskum and its environs (refer to section 3.2.2 for the reasons why this study adopted Landsat despite the availability of other alternative RS images).

3.2.1. Data Sources

The satellite images (Landsat images MSS and TM) covering the study area from 1975-2005 (MSS - PATH 201 , ROW 52 and TM – PATH 187, RAW 52- Worldwide Reference System (WRS)) used in this study were acquired from the archives of the U.S Geological Surveys' (USGS) earth explorer (USGS, 2010). The Landsat programme is a series of earth-observing satellite missions jointly managed by National Aeronautics and Space Administration (NASA) and the USGS (NASA, 2011). More details on the explanation of the activities and characteristics of Landsat can be found on USGS' (2010) and NASA's (2011) websites.

Landsat sensors record reflected and emitted energy from the Earth in various wavelengths of the electromagnetic spectrum (NASA, 2011). The electromagnetic spectrum includes all forms of radiated energy from the earth surface. Note that the human eye is only sensitive to the visible wavelengths of this spectrum (visible spectrum) (Campbell, 2002). Tables 3.1a, 3.1b and 3.1c offer a summary of the Landsat satellite programmes and band characteristics. From table 3.1a, it can be observed that the Landsat programme, which began in 1972 (Landsat 1) is still operational under Landsat 7. Table 3.1b shows the various MSS spectral band designations and their use, while table 3.1c highlighted the TM and ETM+ spectral band designations and their use.

The Landsat images used in this study (1975, 1978, 1984, 1986 & 1987- MSS; 1999 & 2002- TM & 2005- ETM+) were collected in a Tagged Image File Format (TIFF) as separate bands which are then stacked together (on a yearly basis) into a single image in ERDAS Imagine Software before the commencement of any analysis. The reason(s) for selecting Landsat images for this study is discussed in the subsequent section.

3.2.2. Choice of Remote Sensing (RS) Sensors

Even though the general understanding of RS technology by many social scientists and environmental policy makers remains ambiguous, results of RS imagery analyses are now being appreciated in terms of long term environmental planning and evaluation of policy outcome (Schweik & Thomas, 2002). The analysis of RS data for extracting change information as described by Prenzel (2004) involves the following stages:

Table 3.1a: Landsat Satellite Programmes

Satellite	Launched	Decommissioned	Sensors	Resolution (Meters)
Landsat 1	July 23, 1972	January 6, 1978	MSS and RBV*	80 and 80
Landsat 2	January 22, 1975	February 25, 1982	MSS and RBV*	80 and 80
Landsat 3	March 5, 1978	March 31, 1983	MSS and RBV*	80 and 30
Landsat 4	July 16, 1982	June 30, 2001	MSS and TM	80 and 30
Landsat 5	March 1, 1984	(Operational)	MSS and TM	80 and 30
Landsat 6	October 5, 1993	(Did not achieve orbit)	ETM**	30
Landsat 7	April 15, 1999	(Operational)	ETM+**	30 and 15 (panchromatic)

*The return beam vidicom (RBV) was essentially a television camera and did not achieve the popularity of the MSS sensor.

*The sensor onboard Landsat 6 was called the enhanced thematic mapper (ETM). Landsat 7 carries the enhanced thematic mapper plus (ETM+).
Source: USGS, (2006).

Table 3.1b: Landsat MSS Band Designation

Landsats 1,2, & 3 Spectral Bands	Landsats 4 & 5 Spectral Bands	Wavelength (μm)	Use
Band 4 - Green	Band 1 green	0.5 - 0.6	Emphasizes sediment-laden water and delineates areas of shallow water.
Band 5 - Red	Band 2 red	0.6 - 0.7	Emphasizes cultural features.
Band 6 - Near Infrared	Band 3 near Infrared	0.7 - 0.8	Emphasizes vegetation boundary between land and water, and landforms.
Band 7- Near Infrared	Band 4 near Infrared	0.8 - 1.1	Penetrates atmospheric haze best, emphasizes vegetation, boundary between land and water, and landforms.

Note: The four MSS band designations are numbered differently for Landsats 1, 2, and 3 and Landsats 4 and 5.
Source: USGS (2006).

Table 3.1c: Landsat Tm, Etm+ Band Designation

	Spectral Bands	Wavelength (μm)	Use
1	Blue-Green	0.45-0.52	Useful for bathymetric mapping and distinguishing soil from vegetation and deciduous from coniferous vegetation.
2	Green	0.52-0.60	Emphasizes peak vegetation, which is useful for assessing plant vigour.
3	Red	0.63-0.69	Discriminates vegetation slopes.
4	Near Infrared	0.76-0.90	Emphasizes biomass content and shorelines.
5	Mid- Infrared	1.55-1.75	Discriminates moisture content of soil and vegetation; penetrates thin clouds.
6	Thermal Infrared	10.4-12.5	Useful for thermal mapping and estimated soil moisture.
7	Mid-Infrared	2.08-2.35	Useful for mapping hydrothermally altered rocks associated with mineral deposits.

Note: The TM sensor (Landsats 4 and 5) and the ETM+ sensor (Landsat 7) operate in seven spectral bands. Landsat 7 also carries a panchromatic band (visible through near infrared) with 15-m resolution for "sharpening" of multispectral images.

Source: USGS (2006).

(1) data input; (2) data analysis using a quantitative modelling approach; (3) information output; and (4) research and/or decision-making.

Landsat images (MSS, TM and ETM+) were used in this study because of the following reasons:

- The assertion that similar platform images used in any analysis gives a better result (Prenzel, 2004);
- The resolution of Landsat images is very good for this kind of study because it can discriminate land cover with a minimum of 10% cover. This is the minimum amount of vegetation cover an area is required to have in order to be categorised as forest (Wright & Muller-Landau, 2006).
- Landsat images were proven to be good in conservation and in natural resources management at a local and regional level (Sader & Winne, 1992; Tole, 2002; Sader et al., 2003 & Leimgruber et al., 2005).
- A literature search of journal articles using Google scholar revealed more than 6,000 articles between 2009 and 2012 that address deforestation using Landsat satellite imagery.
- The free availability, and easy accessibility over the internet of Landsat images covering large areas through the USGS and the Earth Science Data Interface (ESDI) have added to the success and wider usage of Landsat in recent times (Leimgruber et al., 2005).
- Finally the success of the Landsat programme as summarised by Leimgruber et al. (2005) as follows:

(a) its spatial resolution provides enough detail to detect land cover changes; (b) its data continuity provides records of how the earth's land has changed with time; (c) recent Landsat data acquisition strategies permit cloud-free images.

The image processing and analysis techniques conducted in this study are illustrated in figure 3.1 below. From figure 3.1, it can be observed that several RS analysis techniques are implemented, which provide the means for understanding the variation of the study areas' vegetation change patterns from 1978 to 2005 (refer to chapter 4 for the results and discussions). This is an essential area of the research, which seeks to find answers to

the research question; what evidence is there of deforestation in the study area, and over what time scales? (Refer to chapter 1: 1.1-1.1.2 for detail).

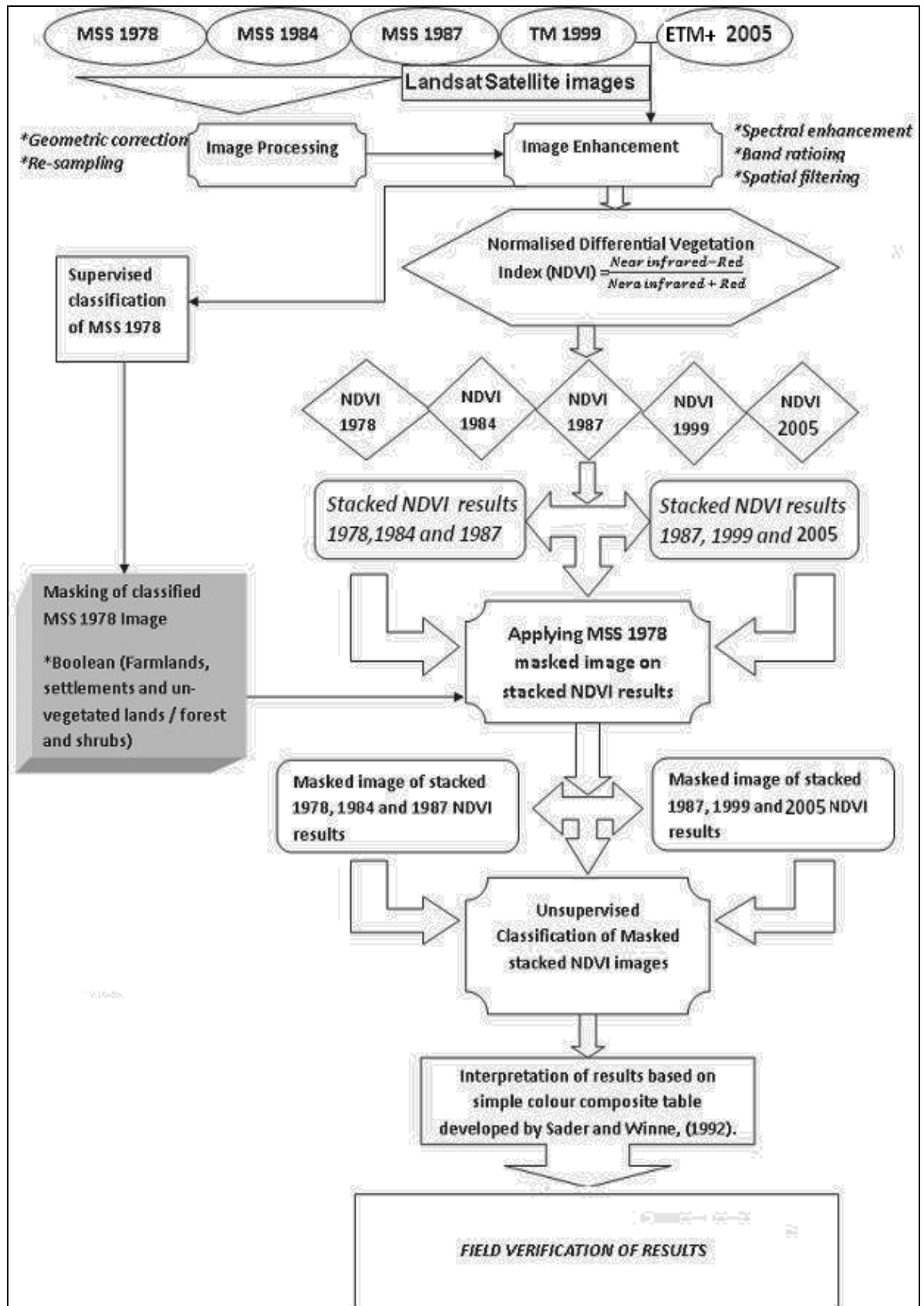


Figure 3.1: A Flow Chart Illustrating the RS Analysis Conducted in this Study
(See appendix 6 for the graphic outputs of the different stages)

Figure 3.1 shows the methodological steps of the RS study approach, which commences with the selection of the best quality images for the study, followed by image enhancements (in order to improve the visual quality of the images), RS modelling, and concludes with RS image classification and the interpretation of the analysed images.

3.2.3. Image Processing and Image Enhancement

From figure 3.1, Landsat images covering the period 1975 and 2005 were acquired at almost similar situations in terms of weather conditions⁵. The topography of the study area is relatively flat (Hess et al., 1995), which Schweik and Thomas (2002) and Prenzel (2004) pointed out to be good for studies using Landsat images. Landsat images of (1978, 1984, 1987, 1999 and 2005) were selected for the purpose of this study after carefully exploring the visual quality (images that have less or are free from cloud and haze) of each image in ERDAS Imagine Software (Shalaby & Tateishi, 2007). The choice of 1978 image as the starting date for this analysis was because the study area suffered a severe drought (Bart, 2005) in the early 1970s, which affected the vegetation of the area. As such, the 1978 image was considered an appropriate year to start the investigation from, because of the probability that the vegetation at that time should have recovered from the effect of the drought.

The 1978, 1984 and 1987 images (MSS Landsat sensors which have 80 metres pixel resolution) were enhanced geometrically (Roy et al., 1991; Jha & Unni, 1994; Cazull & Cialla, 2002 & Shalaby & Tateishi, 2007) and re-sampled (Peterson et al., 2004) to 30 metres in order to allow for direct comparison with the Landsat TM and ETM+ sensor images (1999 & 2005 respectively) (Sader & Winne, 1992). The 2005 ETM+ image was used for the image registration, while the internet programme Google Earth map was used for generating the ground control Points (GCP). The reason for conducting the geometric correction of the MSS images was because; change detection analysis in RS is performed on a pixel-by-pixel basis and therefore any misrepresentation greater than one pixel will provide an inconsistent result of that pixel (Shalaby & Tateishi, 2007, p.32).

Spectral enhancement, band ratioing (Roy et al., 1991; Schweik & Thomas, 2002 & Tole, 2002) and spatial filtering (Peterson et al., 2004) were applied to all the images to

⁵ The images were obtained between November and January when the study area experiences dry season conditions. Acquiring images from a similar period in the year is important in vegetation assessment studies because it reduces the influence of seasonal variation during image interpretation.

enhance their visual quality by improving the obvious distinction between the features on the image. Image enhancement is the process of improving the visual appearance of digital images (Campbell, 2002, p. 151). However, image enhancement has the disadvantage of altering the brightness of the original image which may cause the relationship of the enhanced image with the brightness of the original image to fade (Campbell, 2002). Even though image enhancement is associated with certain problems, manual interpretation was shown to be good at interpreting spatial features and also capable of identifying obscured or subtle features on an enhanced image (Lillisand & Kiefer, 2000). Shalaby and Tateishi (2007) show the significance of image enhancement in RS analysis by emphasising on its implementation in a change detection RS analysis if one is to achieve a better quality image result.

3.2.4. Normalized Difference Vegetation Index (NDVI)

The aim of any land cover change study is to differentiate areas of interest (e.g. forest clearing or afforestation) from a multispectral satellite data, which can be achieved using techniques such as; principal component method, image differentiation method and Normalized Difference Vegetation Index (NDVI). For the purpose of this study, NDVI was selected based on the reasons summarised below.

NDVI is a model that make use of the differential information arising from the distinctive spectral reflectance properties of healthy vegetation in the red (R) and near infra red (NIR) (refer to tables 3.1b and c for details) portion of the electromagnetic (EM) part of the visible light wavelengths (Campbell, 2002; Cazull & Cialla, 2002 & Tole, 2002, p. 94). Sader and Winne (1992); Tole (2002) and Sader et al. (2003) both highlighted the importance of the NDVI model in their respective forest change studies. One of the importances of the NDVI model they emphasised was its tendency of eliminating errors that can affect the spectral properties of vegetation. Since green vegetation surface absorbs proportionally more red light and less infrared than other surfaces, the result of NDVI gives high NDVI values as vegetation increase and less NDVI as vegetation decrease (Sader & Winne, 1992).

The NDVI of each image selected for the analyses were computed using the formula below:

$$\text{NDVI} = \frac{\text{NIR Band} - \text{R Band}}{\text{NIR Band} + \text{R Band}}$$

Equation 3.1

Sader and Winne (1992) found that applying a linear contrast stretching on the NDVI values provides a good result for differentiating vegetated and non vegetated areas. Therefore, a linear stretching was applied to the NDVI model by multiplying the resulting values by 255 (histogram stretch) to increase the contrast of the image as shown in the formula below:

$$\text{NDVI} = (\text{NIR Band} - \text{R Band} / \text{NIR Band} + \text{R Band}) * 255 \quad \text{Equation 3.2}$$

For the MSS images, the vegetation index was computed as shown below:

$$\text{NDVI} = (\text{MSS Band 3} - \text{MSS Band 2} / \text{MSS Band 3} + \text{MSS Band 2}) * 255 \quad \text{Equation 3.3}$$

While for the TM and ETM+ images, the vegetation index was computed as shown below:

$$\text{NDVI} = (\text{TM Band 4} - \text{TM Band 3} / \text{TM Band 4} + \text{TM Band 3}) * 255 \quad \text{Equation 3.4}$$

A subset of the study area was then obtained from each of the resulting NDVI images.

3.2.5. Satellite Image Classification

Image classification in RS is the process of categorising all pixels on an image into land cover themes (Campbell, 2002 & Tso & Mather, 2009). The idea of classification is to group similar pixels into classes that are associated with the information about the categories of interest to the analyst. This is achieved usually by treating individual pixel unit in an image as a composite of values in several spectral bands (Campbell, 2002).

Image classification is an important component of RS (image analysis and pattern recognition) and in some instances may be the sole interest of the analyst (Campbell, 2002). There are two broad types of image classification in RS; Supervised and Unsupervised classifications. The two classification types were implemented in this study at certain stages of the analysis (see figure 3.1 above). The supervised classification was conducted on the MSS 1978 image in order to mask out non-vegetation land cover from vegetation cover; while the unsupervised classification was conducted on the stacked NDVI images (see section 3.2.6 for more detail).

3.2.5.1. Supervised Classification

The MSS 1978 image was selected (because it was the first year considered to begin the analysis with) and classified (supervised classification) (Tso & Mather, 2009). Supervised

classification can be defined as the process of using samples of known identity (i.e. pixels already assigned to informational classes) to classify pixels of unknown identity (i.e. to assign unclassified pixels to one of several informational classes) (Campbell, 2002, p.333). In this study, the training data (pixel samples of identified areas) were gathered using a digital topographic map of the study area, Google Earth map and the author's local knowledge of the study area (refer to chapter 1: 1.4). Campbell (2002) and Tso and Mather (2009) regarded local knowledge as an important tool in finding and identifying training data. Recognised features (training data) such as rivers, road junctions, vegetation cover, settlements and farm lands were identified and manually selected from the pixels of the image, so they could be used later for grouping other similar pixels. The size of the training data (about 100 pixels) identified on each feature was large enough to provide accurate estimates of the properties of each informational class (Campbell, 2002). The position and location of each training data set were spread throughout the image to represent the variation within the image. The classification algorithm was run using ERDAS Imagine Software.

The major advantage of supervised classification is its capability of allowing the analyst to have control of selected informational categories tailored to specific purpose. While this may be an advantage, it can also be a disadvantage given that the analyst imposed a classification structure upon the data, which may not necessarily be the exact class that exist within the data (Campbell, 2002).

Note that the reason for implementing the supervised classification in this study is to use the resulting image to mask out non-vegetation areas since 1978 (the start year of the study) from the analysis. Therefore the classified MSS 1978 image was selected and masked (Radeloff et al., 2000) into vegetation and non-vegetation classes. The MSS 1978 masked image was then overlaid on the stacked RGB-NDVI Images so that those places not categorised as having vegetation in 1978 were omitted from the final analysis. This was performed in order to reduce the effort of considering the whole image in the final analysis and instead only vegetated areas from 1978 were considered and focused in the final results. The results were verified in the field (see section 3.2.7 & appendix 6 for the resulting image).

3.2.5.2. Unsupervised Classification and Image Masking

Unsupervised classification is the identification of natural groups, or structures, within multispectral data (Campbell, 2002, p.322). The main difference between an unsupervised classification and a supervised classification is that unsupervised classification does not require the analyst to select the training data sets in order to classify the target; but instead, the analyst specifies the number of clusters to be generated and the software automatically constructs the clusters (Tso & Mather, 2009, p.54).

Unsupervised classification was conducted in this study on the stacked NDVI images (see figure 3.1 above). The advantages of unsupervised classification is its power of implementing the classification automatically without prior knowledge of the area by the analyst; and therefore the tendency of making human error is minimised because the software algorithm (ERDAS Imagine) automatically show unique classes as distinct units. The disadvantages of unsupervised classification on the other hand include the limited control of the classification menu by the analyst, which may lead to producing classes that are not of interest to the analyst (Tso & Mather, 2009, pp. 323-324).

The main reason for adopting unsupervised classification in this study was that apart from its advantage in generating an automatic spectral classes, there is a special need to generate more classes that can be categorised into the classes specified in the technique adopted in this study (Red, Green and Blue (RGB) - NDVI) (Sader & Winne, 1992). This is discussed further below.

3.2.6. RGB-NDVI Classification

Sader and Winne (1992) developed a technique to visualize vegetation change using three different dates of NDVI imagery simultaneously using the additive colour theory method. The additive colour theory simply suggests that RGB are the "primary" colours of white light and all the three colours combined together will result in white, while the absence of all the three colours will produce black (Hardin & Maffi, 1997). The result of the additive colour combination is depicted in figure 3.2 below:

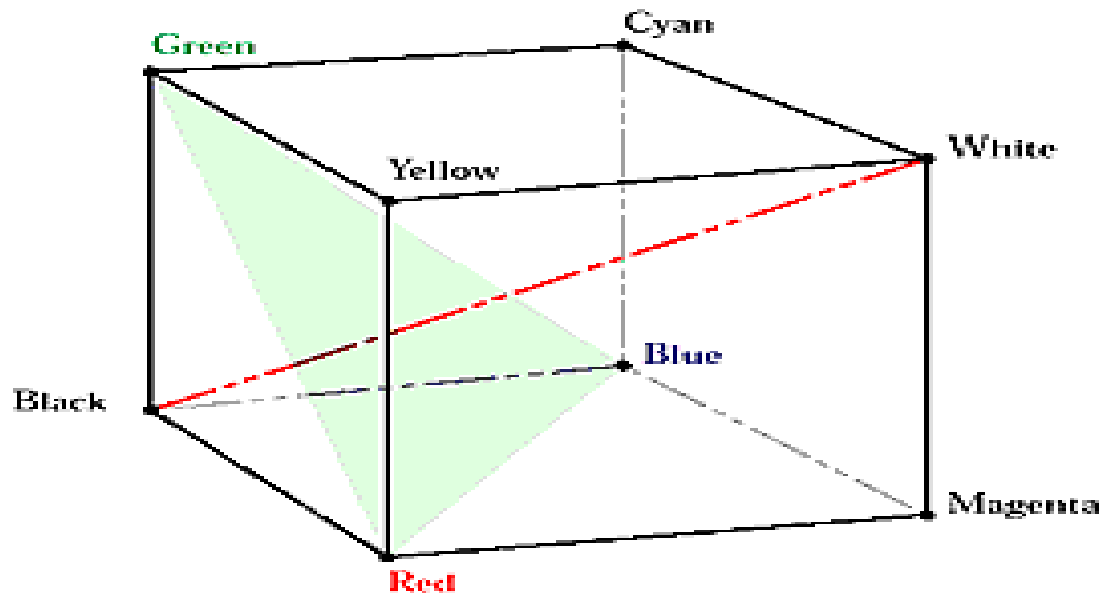


Figure 3.2: Additive Colour Combinations

*Red + Green = Yellow * Red+ Blue = Magenta * Blue + Green = Cyan

The technique works by placing each year of the resulting NDVI image simultaneously on the RGB bands of the ERDAS Imagine Software (see figure 3.2 & table 3.2 below).

Table 3.2: Simplified Interpretation of an RGB-NDVI Image

Image Colour	Blue	Red	Green	Interpretation of Forest / Vegetation Change
	NDVI (1978)	NDVI (1984)	NDVI (1987)	
Black	Low	Low	Low	No Change, no/low biomass
Blue	High	Low	Low	Reduction, 1978 to 1987
Red	Low	High	Low	Regeneration, 1978 to 1984 Reduction 1984 to 1987
Green	Low	Low	High	Regeneration, 1978 to 1987
Magenta	High	High	Low	Reduction, 1984 to 1987
Cyan	High	Low	High	Reduction 1978 to 1984, Regeneration 1984 to 1987
Yellow	Low	High	High	Regeneration 1978 to 1987
Gray	Medium	Medium	Medium	No Change; medium biomass (for example shrubs)
White	High/ Medium	High/ Medium	High/ Medium	No Change; high biomass (for example, trees)

Source: Adapted from Sader and Winne (1992 p. 3062).

Note: High, Medium and Low refers to the NDVI pixel value which is positively correlated to vegetation cover density and green biomass.

This way, some major changes in the vegetation cover between years appear as the additive colour combination. Sader et al. (2003, p.344) summarised the report of some researchers that show the significance of this technique in comparison to the conventional methods used in the study of forest change detection as follows: Previous

studies have shown other methods of change-detection such as principal component method and image differentiation method as most successful and easy to apply. The comparison of principal component method, image differentiation method and RGB-NDVI methods by Hayes and Sader (2001) cited in Sader et al. (2003) found RGB-NDVI method to be the most accurate and efficient of the three methods. RGB-NDVI was the best method, especially when the study involves a time series analysis of many dates, because it has the advantage of incorporating more than two images in the analysis at one time. In contrast, the other two methods can only use two images in their analysis at a time. Another advantage of the RGB-NDVI is that interpreting the results with time (change and no change) is very simple and logical using the additive colour theory combinations. Using this approach, the analyst can visually interpret the magnitude and direction of forest change from the dates under investigation. For these reasons, the method was adopted and implemented in this study.

Using the RGB-NDVI technique, the NDVI image subsets were then stacked together in the following order in the RGB bands of ERDAS Imagine Software (1978, 1984 and 1987 (B, R, G) as one image and 1987, 1999 and 2005 (B, R, G) as another image). The resulting stacked images were then classified (unsupervised) (Tso & Mather, 2009), which is another advantage of the RGB-NDVI method because it “reduces the analyst effort in selecting histogram thresholds for the several pixels, and was therefore more straight forward and time efficient” Sader et al. (2003, p. 344). The resulting images were then interpreted based on the classes recommended by Sader and Winne (1992) (see table 3.2 and appendix 6 for image results).

3.2.7. Remote Sensing (RS) Image Results Validation (Field Investigation)

The RS image interpretation was successful because ancillary information on the area was available and used during the process. Such information includes the personal knowledge of the study area by the interpreter and existing maps and statistics of the area. Because the interpreter has personal knowledge of the study area, interpreting the images was possible with a high degree of confidence. The visual interpretation of the images using the RGB-NDVI techniques explained earlier gave a general idea about the changes that have occurred in the forest area over the period of investigation. However, the need for field verification was emphasised by Tole (2002) for accuracy assessment. Therefore, the accuracy of the interpreted images was verified by comparing some selected areas on the

analysed images in the field as part of ground-truthing. In the process, two afforestation sites and three other areas were visited (refer to chapter 7: 7.4.4.1 for more detail) based on the selected sites obtained from the analysed image prior to field visits. In addition, other places visited during the field investigation were areas identified to the researcher as fuelwood collection centres by the local commercial fuelwood vendors (see chapter 9:9.3.1.1). Through this process, an opportunity for direct comparison of the activities of the fuelwood vendors in the forest area with the RS image results was achieved.

The method use in the field include the use of Global Positioning System (GPS) for recording location readings and a digital camera for taking photographs of the activities in the areas visited. These data were later verified on the images using Google Earth images as a reference point in order to ascertain the reliability of the RS interpretation. The results and discussion of these findings are reported in chapter 4.

Chapter 4: Vegetation change study using Remote Sensing (RS)

4.1. Introduction

The literature reviewed in chapter two identified the need for repeated studies of the vegetation of the northern dry belt of Nigeria as a result of over exploitation and the vulnerability of the region in sustaining its future supply of fuelwood. Such studies can be useful to both policy makers and researchers in prioritising management mechanisms in the worst affected areas. This chapter presents the results and discussions of the analysis undertaken using Remote Sensing (RS) that explore the trend of vegetation change from 1978 to 2005 in Potiskum and environs as demonstrated in chapter 3. The first section of the chapter presents the results of the vegetation change patterns, as well as the results of accuracy assessment that validates the accuracy level of the analysed images. The second section (section 4.2) presents the discussions of the results and the possible reasons for the observed changes with regard to the influence of such factors as population, rainfall, political inclination and fuelwood collection with reference to existing literature. The last section of the chapter summarises the findings of the chapter as well as a discussion of the major critiques and conclusions of the findings.

4.1.1. Vegetation Change Patterns

Figures 4.2a and 4.2b are the resulting RGB-NDVI (Red, Green, and Blue (RGB) – Normalized Difference Vegetation Index (NDVI)) images after applying a filter on figures 4.1a and 4.1b⁶. The pixel colours (black, blue, red, green, magenta, cyan, yellow, gray & white) are the products of the assignment of the NDVI images of 1978 on blue, 1984 on Red and 1987 on Green (figures 4.1a & 4.2a); and 1987 on blue, 1999 on Red and 2005 on the Green components of the RGBCLUS package in the ERDAS Imagine Software (figures 4.1b & 4.2b) (refer to chapter 3: 3.2.4 & 3.2.6 for more detail).

Tables 4.1a and b describe the response and the percentage contribution of the study area's vegetation cover in each of the three years in terms of high, medium and low vegetation respectively from the resulting RGB-NDVI images.

⁶ Note that the results of the vegetation area change pattern of Potiskum and environs, including all statistical analysis, were achieved from the original results of the RGB-NDVI images (1978-2005) before any statistical filtering was applied on to the images (figures 4.1a and 4.1b). However, for a better cartographic visualization of the patterns of vegetation changes (due to the numerous tiny pixels observed on the images- figures 4.1a and 4.1b), a 7x7 low-pass window median filter (Mauz, 2002) was applied to the images in order to reduce their pixel noise.

From figures 4.2 a and b and tables 4.1 a and b, the interpretation of colours such as; black, blue, green, magenta, yellow, gray and white revealed a vegetation change pattern in only one direction, which is an indication of either a decrease or an increase of vegetation between two years or throughout the three years period. While colours, such as red and cyan revealed a pattern of vegetation change in two directions; that is a combined situation of both increase and decrease of vegetation throughout the three years period.

The percentage of the study area's vegetation cover was estimated using the ERDAS Imagine RGBCLUSTER routine based on the pixels values of the resulting colours of the RGB-NDVI images. Black colour is an indication of the absence of vegetation (i.e. water bodies, bare surface or buildings) and is therefore representing no/low vegetation throughout the epochs. The no/low vegetation of the study area's land surface accounted for 43.5% from 1978-1987 (table 4.1a) and 41.2% from 1987-2005 (table 4.1b) respectively.

White and gray colours both indicate vegetation cover maintenance in terms of high (trees) and medium (shrubs) respectively throughout the entire periods. The values of these two colours were jointly reported together as high/medium vegetation given that they are both accentuating maintenance of vegetation cover throughout the years. The high/medium vegetation cover accounted for 16.2% from 1978-1987 (table 4.1a) and 12% from 1987-2005 (table 4.1b) respectively.

Blue and magenta colours both indicate a level of vegetation cover reduction. While blue colour emphasises a reduction in the vegetation cover after the first year which continued throughout the subsequent years, the magenta colour emphasises a reduction of vegetation cover after the second year (1984-1987- table 4.1a & 1999-2005 -table 4.1b). This shows that there was a reduction in the study area's vegetation cover after the first year by about 15.3% from 1978-1987 and 30.9% from 1987-2005 respectively. Similarly, there was a reduction of vegetation cover after the second year by about 0.7% from 1984-1987 (table 4.1a) and 0% from 1999-2005 (table 4.1b), which means that the vegetation was relatively similar in size between 1999 and 2005.

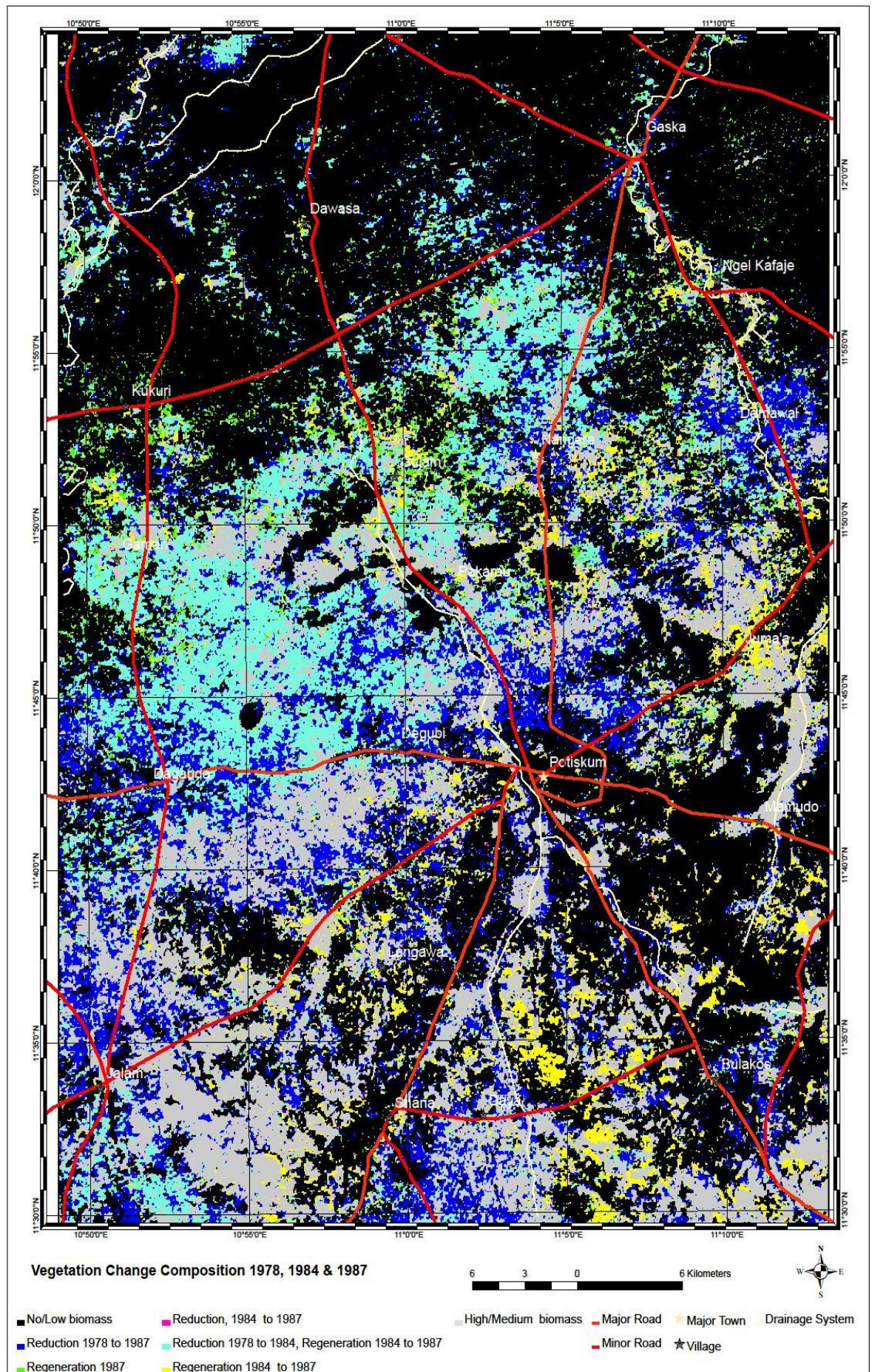


Figure 4.1 (a): Unfiltered RGB-NDVI Resulting Image 1978-1987

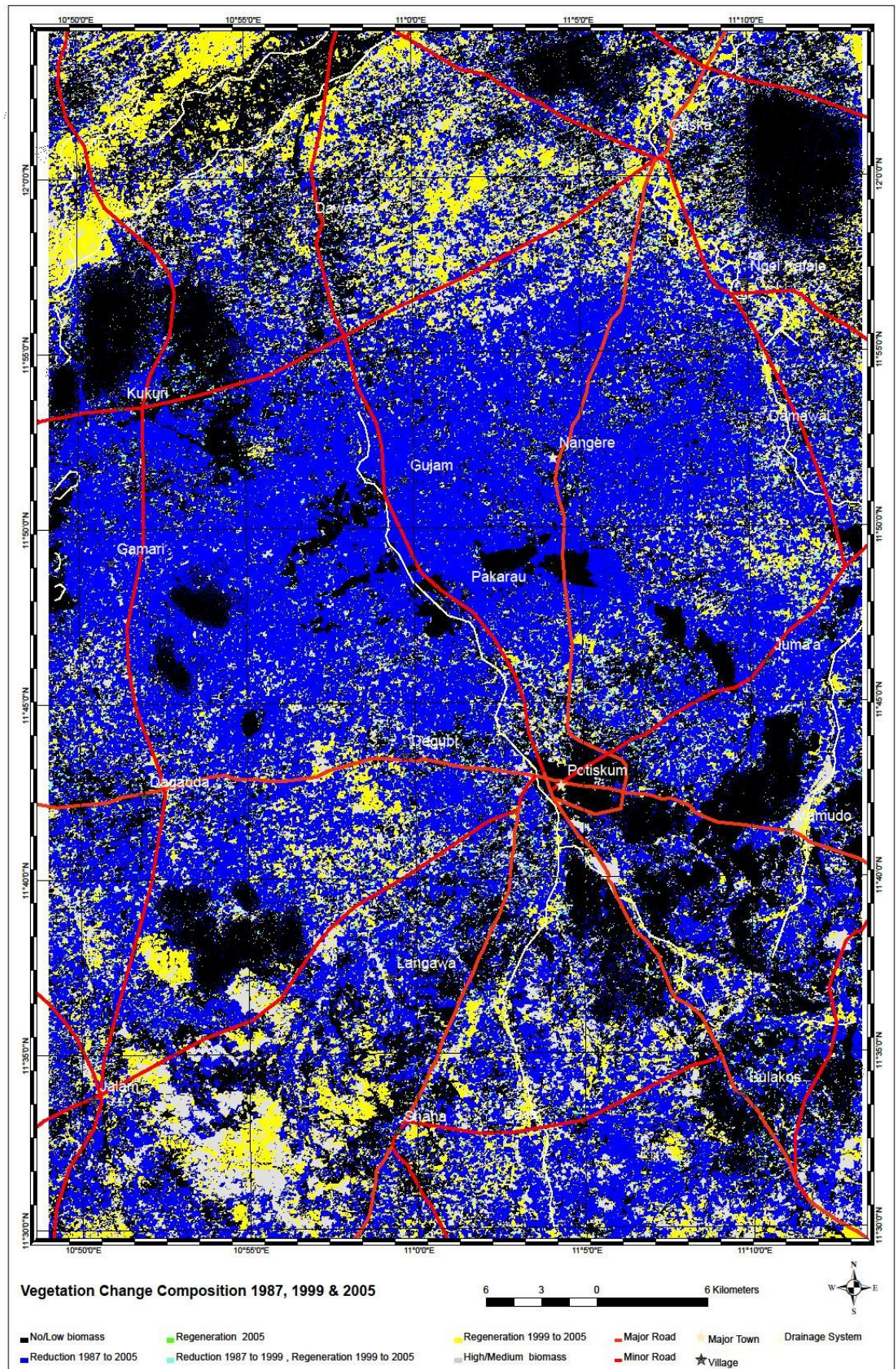


Figure 4.1 (b): Unfiltered RGB-NDVI Resulting Image 1987-2005

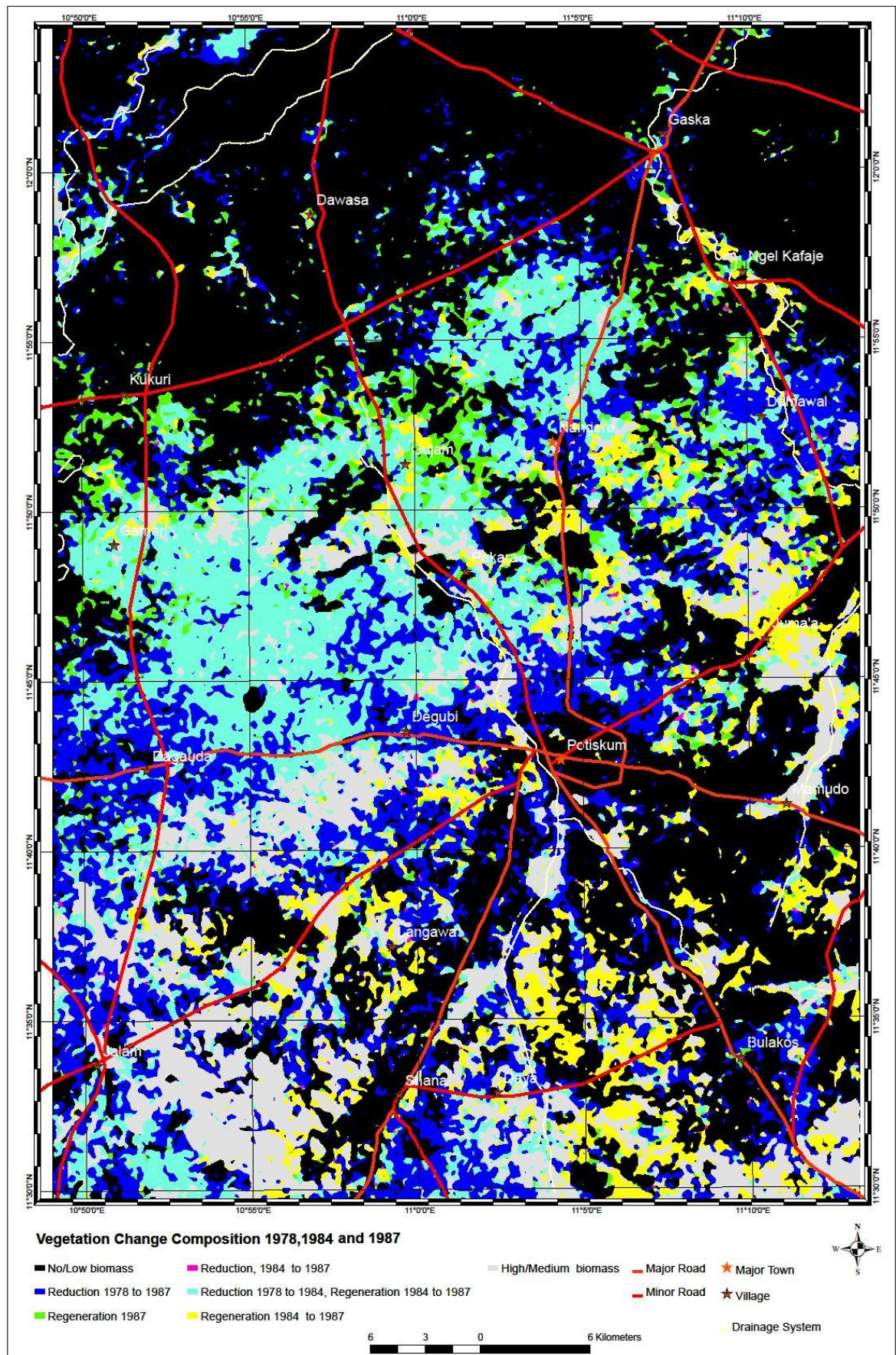


Figure 4.2 (a): Filtered RGB-NDVI Resulting Image 1978-1987

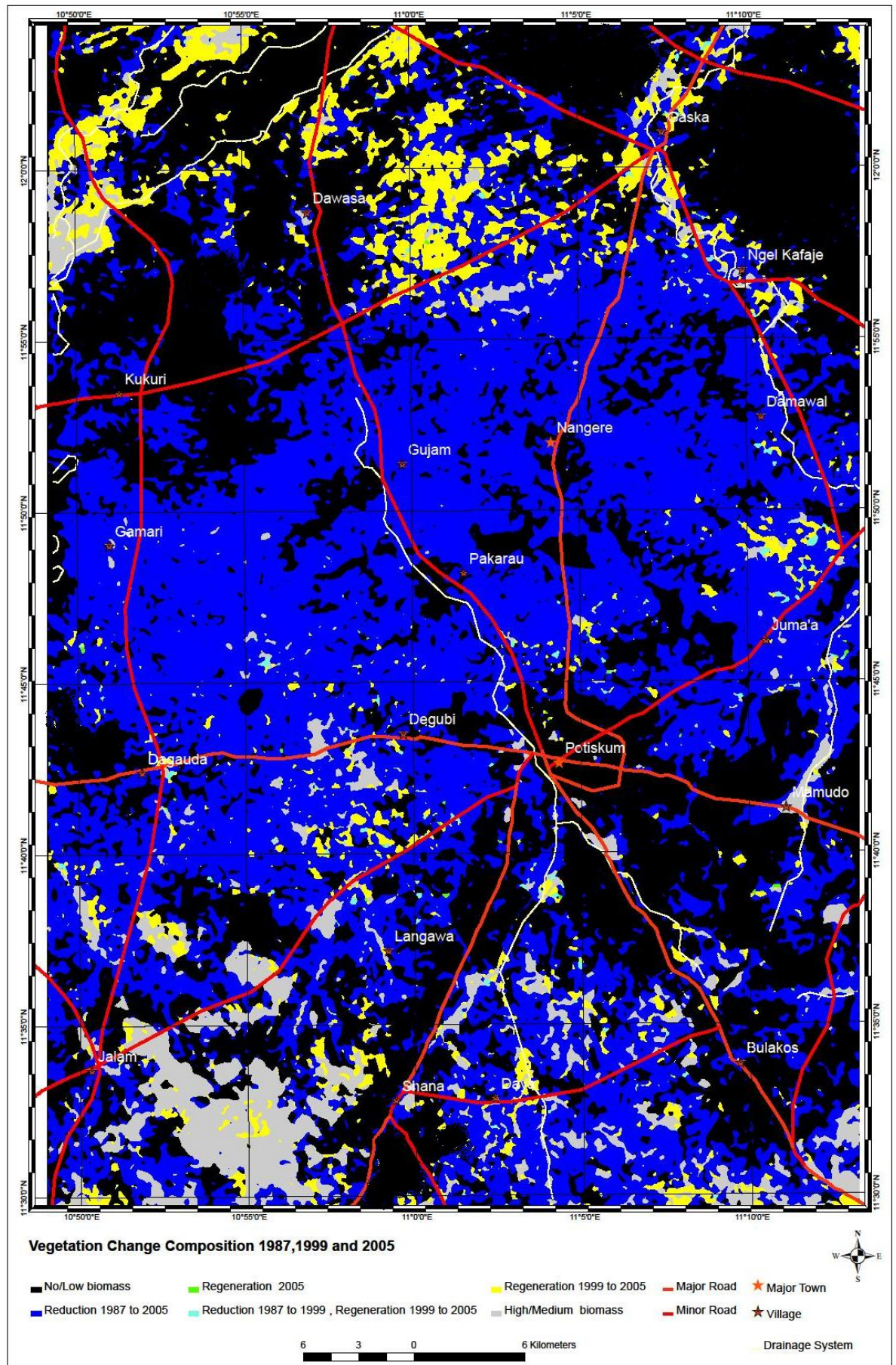


Figure 4.2 (b): Filtered RGB-NDVI Resulting Image 1987-2005

Table 4.1a: Percentage of Vegetation Area Changed- (RGB-NDVI image 1978-1987)

Image Colour	Blue (NDVI 1978)	Red (NDVI 1984)	Green (NDVI 1987)	Interpretation of Vegetation Change	Area (%)
Black	Low	Low	Low	No/low vegetation 1978 to 1987	43.5
Blue	High	Low	Low	Reduction, 1978 to 1987	15.3
Red	Low	High	Low	Regeneration, 1978 to 1984 Reduction 1984 to 1987	0.0
Green	Low	Low	High	Regeneration, 1978 to 1987	5.3
Magenta	High	High	Low	Reduction, 1984 to 1987	0.7
Cyan	High	Low	High	Reduction 1978 to 1984, Regeneration 1984 to 1987	12.2
Yellow	Low	High	High	Regeneration 1984 to 1987	6.8
Gray / White	Medium/ High	Medium/High	Medium/High	Medium or high Vegetation 1978 to 1987	16.2

Table 4.1b: Percentage of Vegetation Area Changed- (RGB-NDVI image 1987-2005)

Image Colour	Blue (NDVI 1987)	Red (NDVI 1999)	Green (NDVI 2005)	Interpretation of Vegetation Change	Area (%)
Black	Low	Low	Low	No/low vegetation 1987 to 2005	41.2
Blue	High	Low	Low	Reduction, 1987 to 2005	30.9
Red	Low	High	Low	Regeneration, 1987 to 1999 Reduction 1999 to 2005	0.4
Green	Low	Low	High	Regeneration, 1987 to 2005	1.6
Magenta	High	High	Low	Reduction, 1999 to 2005	0.0
Cyan	High	Low	High	Reduction 1987 to 1999, Regeneration 1999 to 2005	2.6
Yellow	Low	High	High	Regeneration 1999 to 2005	10.8
Gray / White	Medium/High	Medium/High	Medium/High	Medium or high vegetation 1987 to 2005	12.0

Green and yellow colours represent an increase in vegetation cover at certain periods. While yellow emphasises an increase in vegetation cover in the last two years after the first year (1984-1987 and 1987-2005), the green colour represents an increase in vegetation cover in the last year only (1987 table 4.1a and 2005 table 4.1b). This shows that the vegetation of the study area increased by about 6.8% in 1984 – 1987 (table 4.1a); and 10.8% in 1999-2005 (table 4.1b). Similarly, there was about 5.3% regeneration in the vegetation cover in 1987 (table 4.1a) and 1.6% in 2005 (table 4.1b).

Red and cyan colours both represent an increase and decrease in the vegetation cover throughout the periods. Red colour indicates an increase in the vegetation cover in the second year only (1984- table 4.1a and 1999- table 4.1b). The red colour accounts for 0% (table 4.1a) and 0.4% (table 4.1b). Cyan colour is the opposite of Red colour in terms of interpretation because it represents an increase in the vegetation cover in the first and last year only; whilst the second year (middle year) indicates a decrease in the vegetation. The cyan colour accounts for 12.2% of the study area's vegetation cover from 1978-1987 (table 4.1a) and 2.6% from 1987-2005 (table 4.1b).

4.1.2. Accuracy Assessment

“Accuracy defines “correctness”; it measures the agreement between a standard assumed to be correct and a classified image of unknown quality” (Campbell, 2002, p.383). Campbell argued that the evaluation of accuracy seldom explicitly considers precision, but rather the accuracy should be appropriate for the purpose at hand. Therefore, a high accuracy is recommended in order to have estimated values that are consistently close to an accepted reference value (Campbell, 2002, p.383). Two types of accuracy assessments are used in this study (Campbell, 2002). They are as follows:

- 1- “Producers Accuracy (PA)” that corresponds to error of omission (exclusion), which is the percentage of a given class that is correctly identified on map.
- 2- “Users Accuracy (UA)” that corresponds to error of commission (inclusion), which is the probability that a given pixel will appear on the ground as it is classed. See box 4.1 for more detail.

The majority of vegetation map classifications were assessed using topographic maps as the reference map. It is important at this stage to point out that updating such topographical maps to include all vegetation coverage in most Developing Countries (DC)

(including Nigeria) is not very reliable and is therefore not useful when assessing accuracy. For example, the author's personal observation at the time of writing revealed that the most up-to-date map of the study area was produced in 1985 (East View Cartographic- <http://www.cartographic.com/hub/index.asp>). As twenty seven years have now elapsed, this map cannot be considered to contain information that reflects current realities on ground. This lack of regular update of the topographical maps of Nigeria was also highlighted by Nnabugwu (2012) in a Nigerian local news paper (Vanguard of 7/2/2012, p. 30), who quoted the Nigerian Surveyor General (Mr. Peter Nwilo) saying "*the last time Nigeria was comprehensively mapped was more than 30 years ago*". Therefore, the lack of conviction and failure from both commercial and government sides to regularly update the maps revealed some of the difficulties in obtaining a reliable and up to date topographical map of the study area that can be used reliably as a reference map. For this reason as well as the choice of technique used in this study (RGB-NDVI- as against the conventional use of single image at one time), the accuracy assessment was achieved using the original NDVI images for each year as the reference map. Cohen et al. (1998); Sader et al. (2003) and Sader et al. (2008) used similar methods using the original Landsat TM image as the reference image in their respective classification accuracy assessments.

Using the accuracy assessment tool in ERDAS Imagine Software, the accuracy of the classified RGB-NDVI Images was assessed. In addition to using the NDVI images as the reference maps, each year's NDVI images were further examined using Google images in conjunction with personal knowledge of the study area (Sader et al., 2008). This method obviates the need for using topographic maps due to the possibilities of error and misrepresentation in determining the correct classes. Due to the nature of the technique chosen in the classification process as explained earlier, each NDVI year was separately considered and recorded during the accuracy assessment.

The algorithm used a stratified random sampling method (Mauz, 2002) to identify 54 sample points on each of the images (6 points for each of the 9 classes identified- see Table 4.2). The position (pixel values) of each of the 54 reference points were separately identified and determined on each of the two classified composite images (RGB-NDVI 1978, 1984 & 1987; & RGB-NDVI 1987, 1999 & 2005). By repeating the whole process on each image using their individual NDVI years (see figure 4.3), the overall percentage accuracy was achieved by summing the percentages of each set of images and divide the outcome figure by 3 (number of years per image). The result is presented in table 4.2.

Box 4.1: Accuracy Assessment

Overall Accuracy is the number of incorrect observations divided by the number of correct. It is calculated as calculated as:

Number of correct plots class types determined from reference source / total number of plots *100

User's Accuracy is a measure of how well the classification performed in the field. The user's accuracy details errors of commission. An error of commission results when a pixel is committed to an incorrect class. It is calculated as:

Number correctly identified in a given map class / Number claimed to be in that map class *100

Producer's Accuracy is a measure of how accurately the analyst classified the image data. The producer's accuracy details the errors of omission. An error of omission results when a pixel is incorrectly classified into another category. The pixel is omitted from its correct class. It is calculated as:

Number correctly identified in reference plots of a given class / Number actually in that reference class *100

Source: Campbell, (2002).

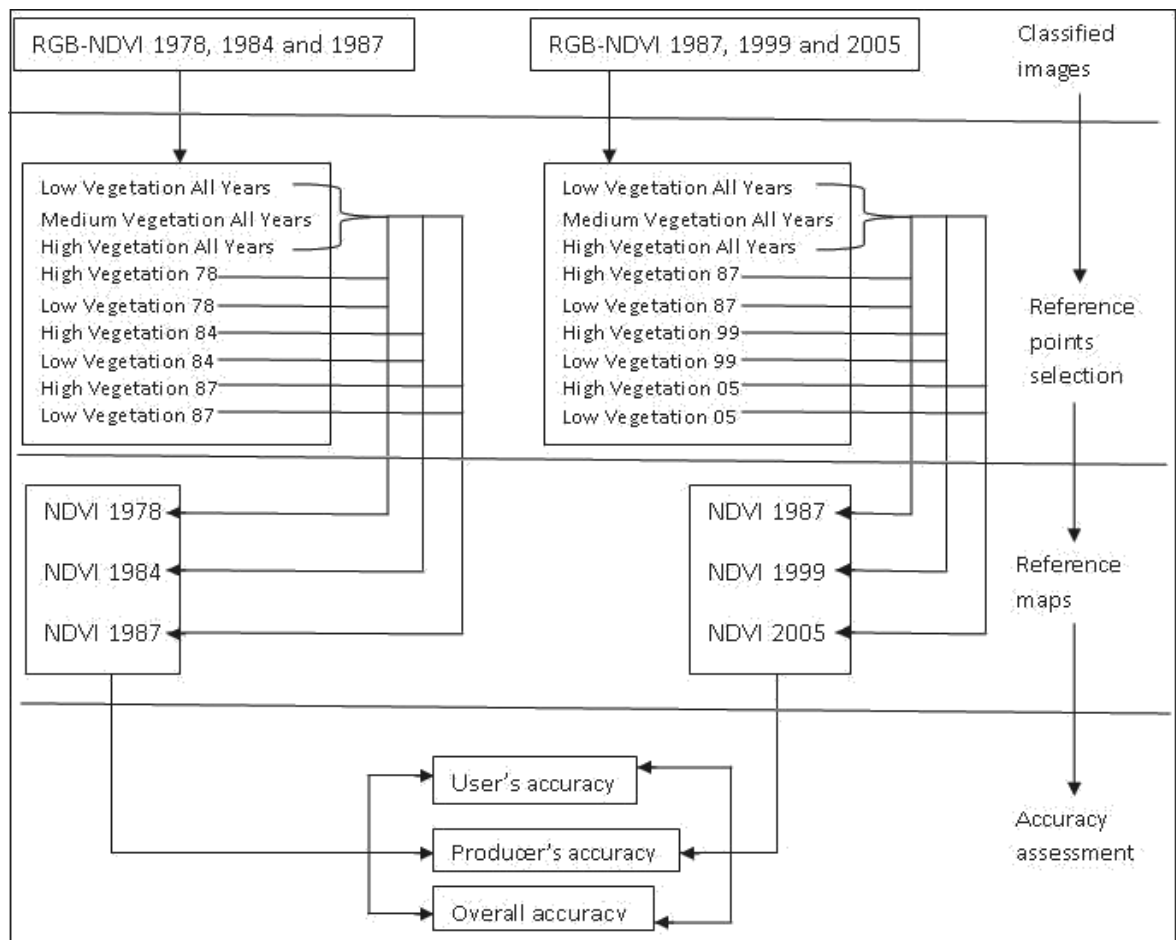


Figure 4.3: The Algorithm Used in Assessing the Accuracy of the Result

Table 4.2: RGB-NDVI Nine Classes Comparative Accuracy Assessment Results Using Fifty Four Random Sample Reference Points

Class Name	Producer's Accuracy	User's Accuracy		
RGB-NDVI 1978, 1984 and 1987				
Low Vegetation All Years	77.8%	44.4%		
High Vegetation 78	100.0%	55.6%		
High Vegetation 84	66.7%	50.0%		
High Vegetation 87	100.0%	72.2%		
Low Vegetation 87	100.0%	72.2%		
Low Vegetation 84	100.0%	88.9%		
Low Vegetation 78	100.0%	77.8%		
Medium Vegetation All Years	28.8%	94.4%		
High Vegetation All Years	83.3%	83.3%		
RGB-NDVI 1987, 1999 and 2005				
Low Vegetation All Years	82.2%	61.1%		
High Vegetation 87	100.0%	72.2%		
High Vegetation 99	100.0%	83.3%		
High Vegetation 05	100.0%	94.4%		
Low Vegetation 05	100.0%	83.3%		
Low Vegetation 99	100.0%	100.0%		
Low Vegetation 87	100.0%	88.9%		
Medium Vegetation All Years	46.3%	88.9%		
High Vegetation All Years	95.2%	100.0%		
	RGB-NDVI 1978, 1984 and 1987		RGB-NDVI 1987, 1999 and 2005	
	Producer's Accuracy	Users Accuracy	Producer's Accuracy	User's Accuracy
Overall Classification Accuracy	84.1%	71.0%	91.5%	85.8%
Overall High Vegetation Classification Accuracy	75.8%	71.1%	88.3%	87.8%
Overall Low Vegetation Classification Accuracy	94.4%	70.8%	95.6%	83.3%

From table 4.2, all the classification accuracy results (the overall classification accuracy, overall high vegetation classification accuracy and overall low vegetation classification accuracy) show similar patterns of agreement with the NDVI image reference points for the change detection maps (1978-1987 & 1987-2005). The range of the agreement is between 70% and 95.6% respectively for both UA and PA. This high range of accuracy results revealed a satisfactory agreement between the sample control points and the RGB-NDVI classified images.

Table 4.2 also revealed a certain degree of confusion in assigning the correct classes between the years as observed in the “Medium Vegetation All Years” and “Low Vegetation All Years”, where there was a high level of disagreement between the PA and UA. For example, the PA indicated a low percentage accuracy of 28.8% and 46.3% in the “Medium Vegetation All Years classes” for the two images, while the UA of the same class shows a high percentage of 94.4% and 88.9% respectively for the two images. This confusion could be as a result of misinterpreting medium vegetation with high vegetation in the first set of images (RGB-NDVI 1978, 1984 & 1987); which could also be the reason why there was an almost similar accuracy percentage of “71%” in the UA report (RGB-NDVI 1978, 1984 & 1987). However, because the confusion is only common in the first set of RGB-NDVI image classification (1978, 1984 & 1987) suggests that its occurrence could be as a result of the effect of the first MSS image of 1978 used in the analysis, which has the least visual quality compared to the rest of the four images used (1984, 1987, 1999 & 2005).

Based on these reasons, which are all considered in the analysis, the overall classification accuracy report is adjudged as being high enough (Powell et al., 2004) to justify the resulting RGB-NDVI classified images (figures 4.1a & b & tables 4.1a & b).

4.1.3. Percentage of Vegetation Area Changed

This section used the pixel values of the unfiltered classified images (black, blue, red, green, magenta, cyan, yellow, gray & white- see section 4.1.1) and obtained the figures of the changes that have occurred from 1978 to 2005. This was achieved using a statistical clustering procedure that reduced the number of the vegetation classes into 2 major change patterns for ease of discussion – No/Low vegetation; and High/Medium vegetation classes.

The percentage of the study area's vegetation change was calculated from the results obtained in section 4.1. The area of vegetation change for each year is illustrated in figure 4.4 below. The results from figure 4.4 revealed that about 44.4% of the study area was covered with vegetation in 1978. This percentage reduced to about 27.5% in 2005. The years of 1984 and 1999 witnessed a little over 23% change in their vegetation cover compared with the years of 1978 and 1987 where each accounted for about 40% vegetation cover (figure 4.4).

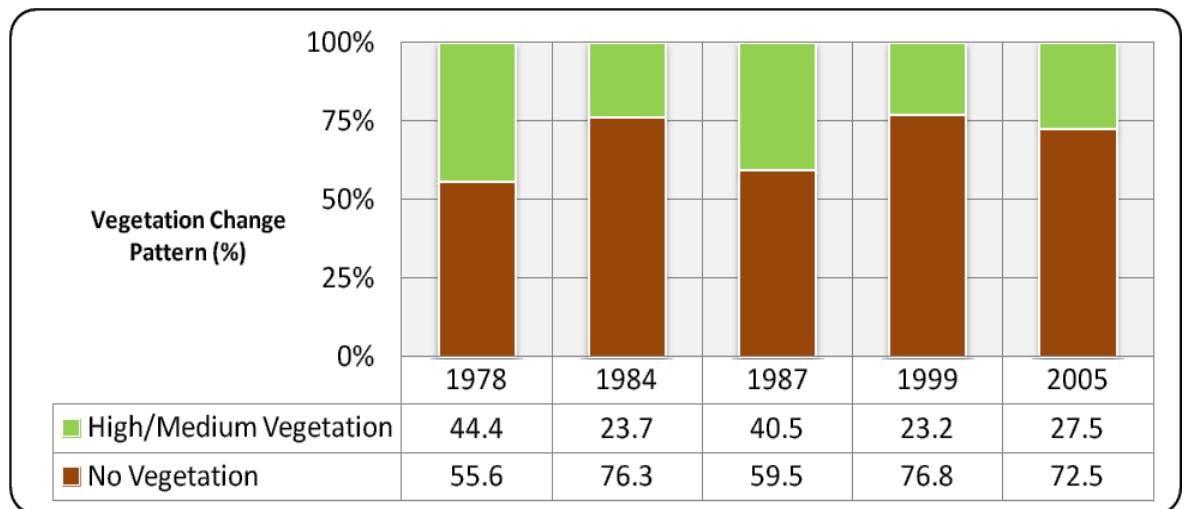


Figure 4.4: Percentage of Vegetation Area Changed Pattern from 1978-2005 (Annual Basis)

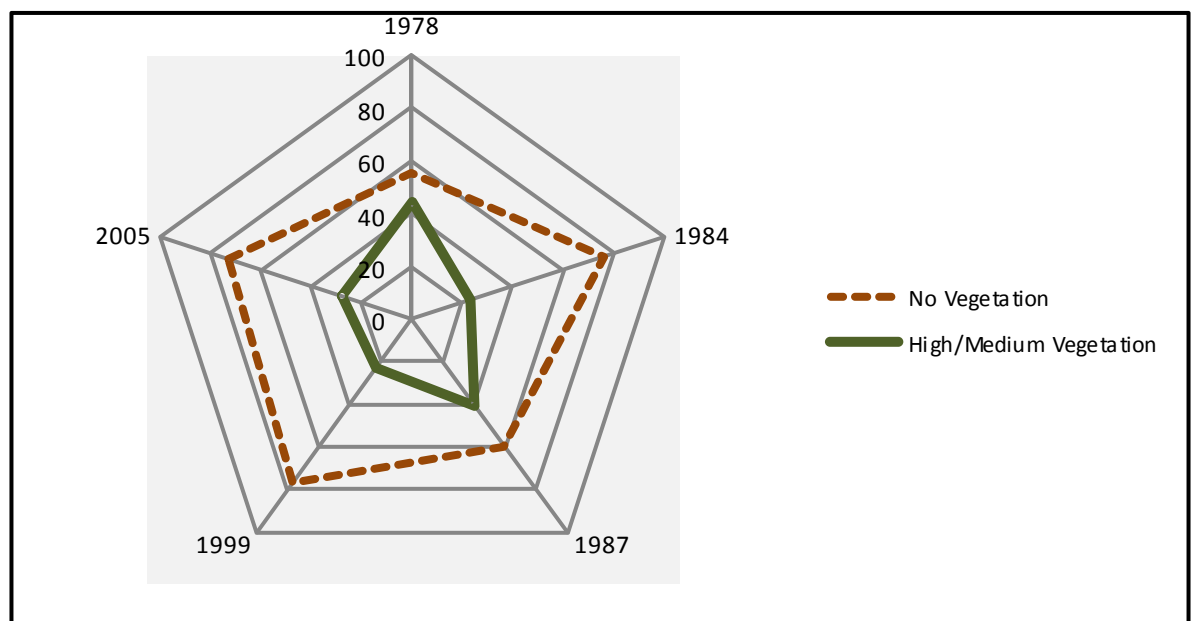


Figure 4.5: Percentage of Temporal Variations of Vegetation Area from 1978-2005

Figure 4.5 shows the annual interval percentage of vegetation area change in the study area. The change pattern revealed an increase of about 16.8% in the vegetation from 1984 to 1987 and an increase of about 4.3% from 1999 to 2005. However, apart from these two incidences of vegetation increase in the study area over the years considered in this analysis, all other periods witnessed a substantial decline in their vegetation cover. The periods from 1978 to 1984, and 1987 to 1999 witnessed vegetation decline of about -20.7% and -17.3% respectively. The vegetation increase from 1984-1987 is quite large compared with an increase of just about 4% from 1999 to 2005 and the large reduction of vegetation from 1978 to 1984 and 1987 to 1999.

An important observation in the vegetation change trend is the manner in which the vegetation oscillated continuously within the period of investigation. As there was a reduction in 1984 and 1999, there was also an increase in 1987 and “slightly” in 2005 (figure 4.5).

4.1.4. Mapping the Development of Vegetation Change Patterns

The vegetation change maps are presented in figures 4.6, 4.7, 4.8, 4.9 and 4.10. A close observation of the maps indicated that the 1984 map (figure 4.7) shows a massive reduction in the vegetation cover with areas around Nangere in the north central, Dagauda in the west, Jalam in the south-west, Bulakos in the south-east and Potiskum in the central area of the map all having their vegetation cover reduced compared with similar places in 1978 (figure 4.6) and 1987 (figure 4.8) when the vegetation cover is large. The minimal increase in the vegetation cover in 2005 (figure 4.10) as compared with 1999 (figure 4.9) is quite difficult to visually differentiate on the two maps. Nevertheless, the maps serve as the key to the visual impression of vegetation change that has occurred in the area since 1978.

Figure 4.11 shows the area of vegetation change patterns in hectares (Ha) from 1978-2005. The results which followed a similar pattern with the area percentage change reported earlier in section 4.1.3 shows that the study area's vegetation cover has reduced from 133,954 Ha to 42,167 Ha respectively from 1978 to 2005. In order to test the validity of these changes (vegetation increase and decrease) over the years; an Analysis of Variance (ANOVA) statistical test was applied to the results.

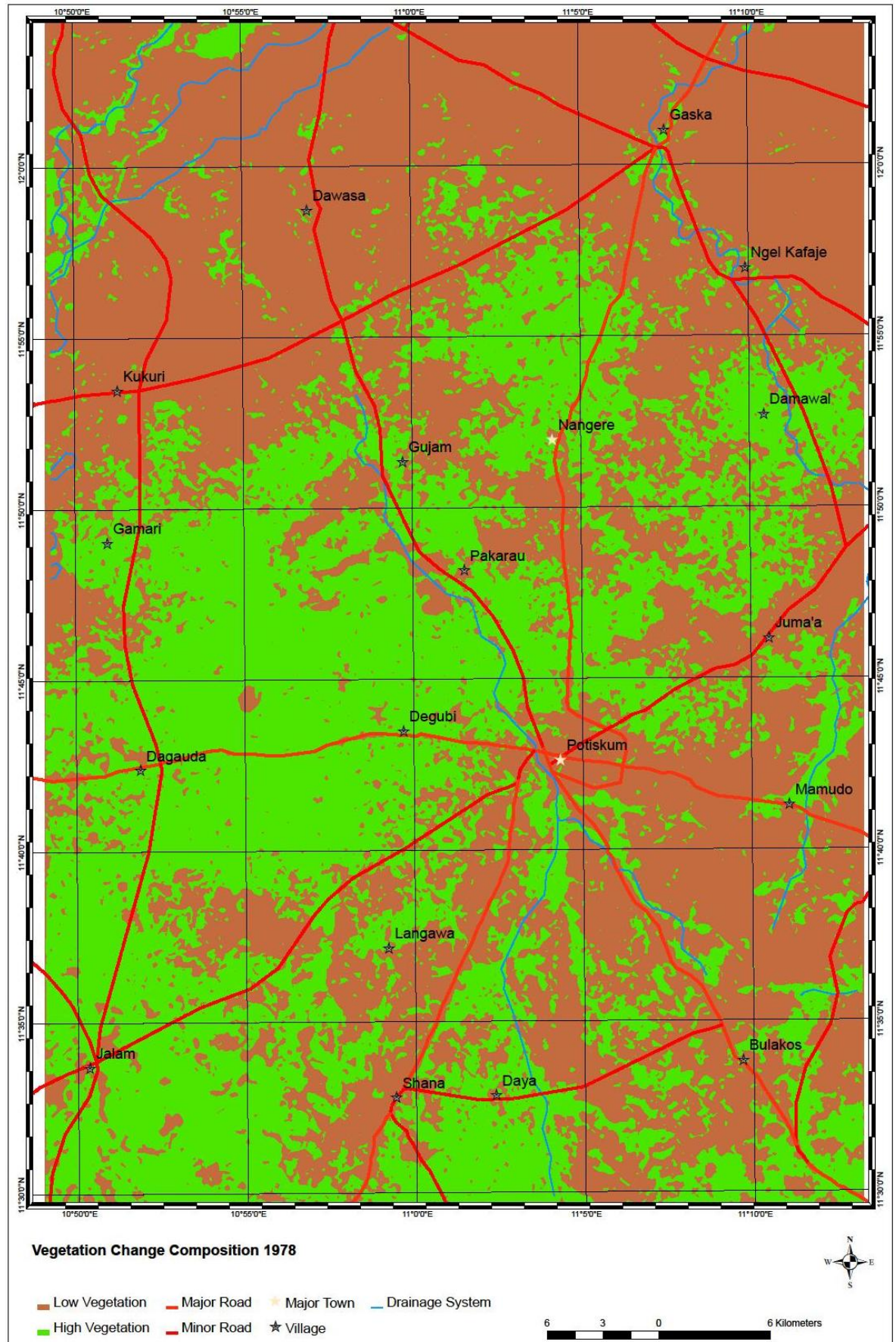


Figure 4.6: Vegetation Change Pattern in 1978

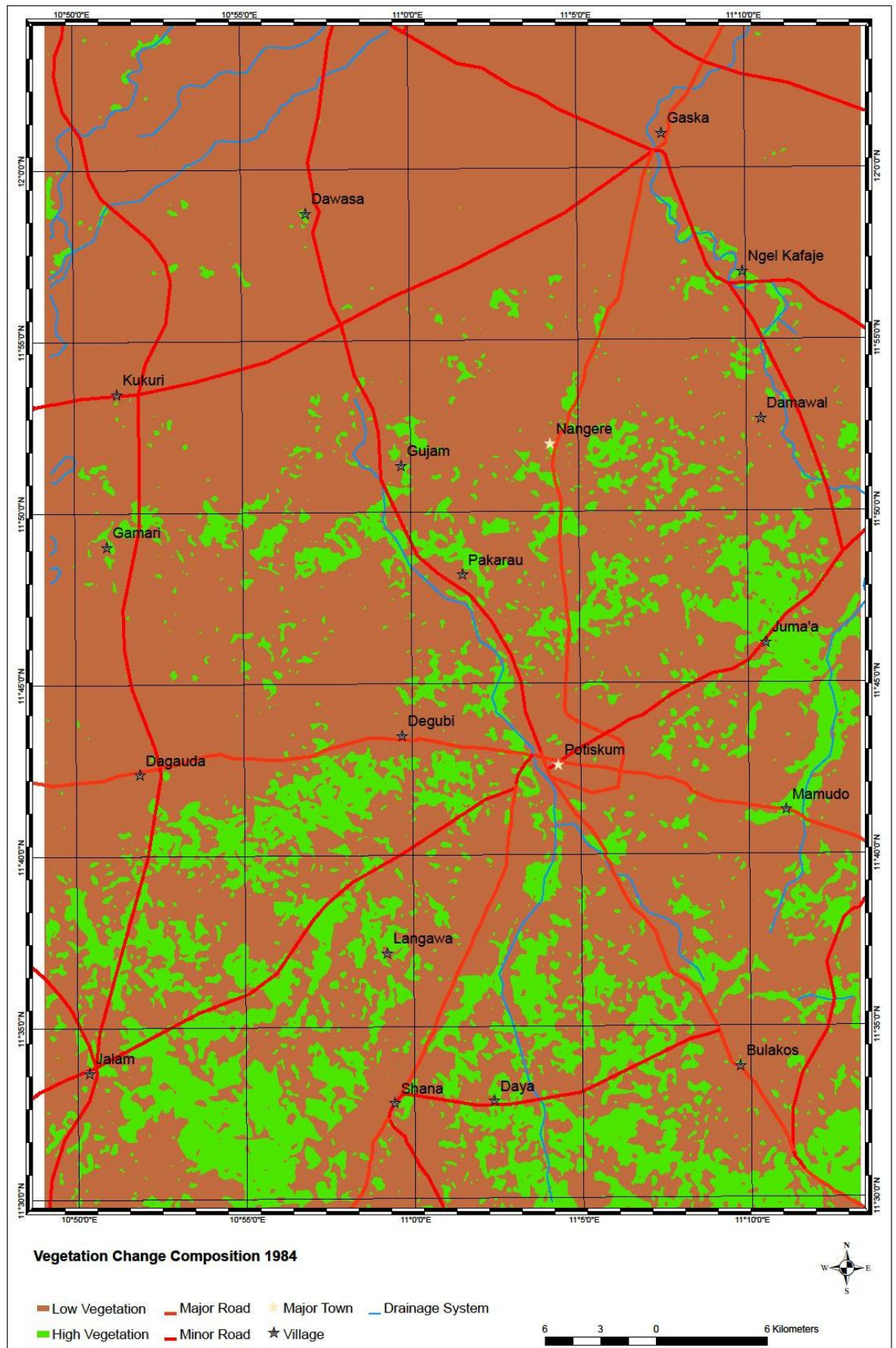


Figure 4.7: Vegetation Change Pattern in 1984

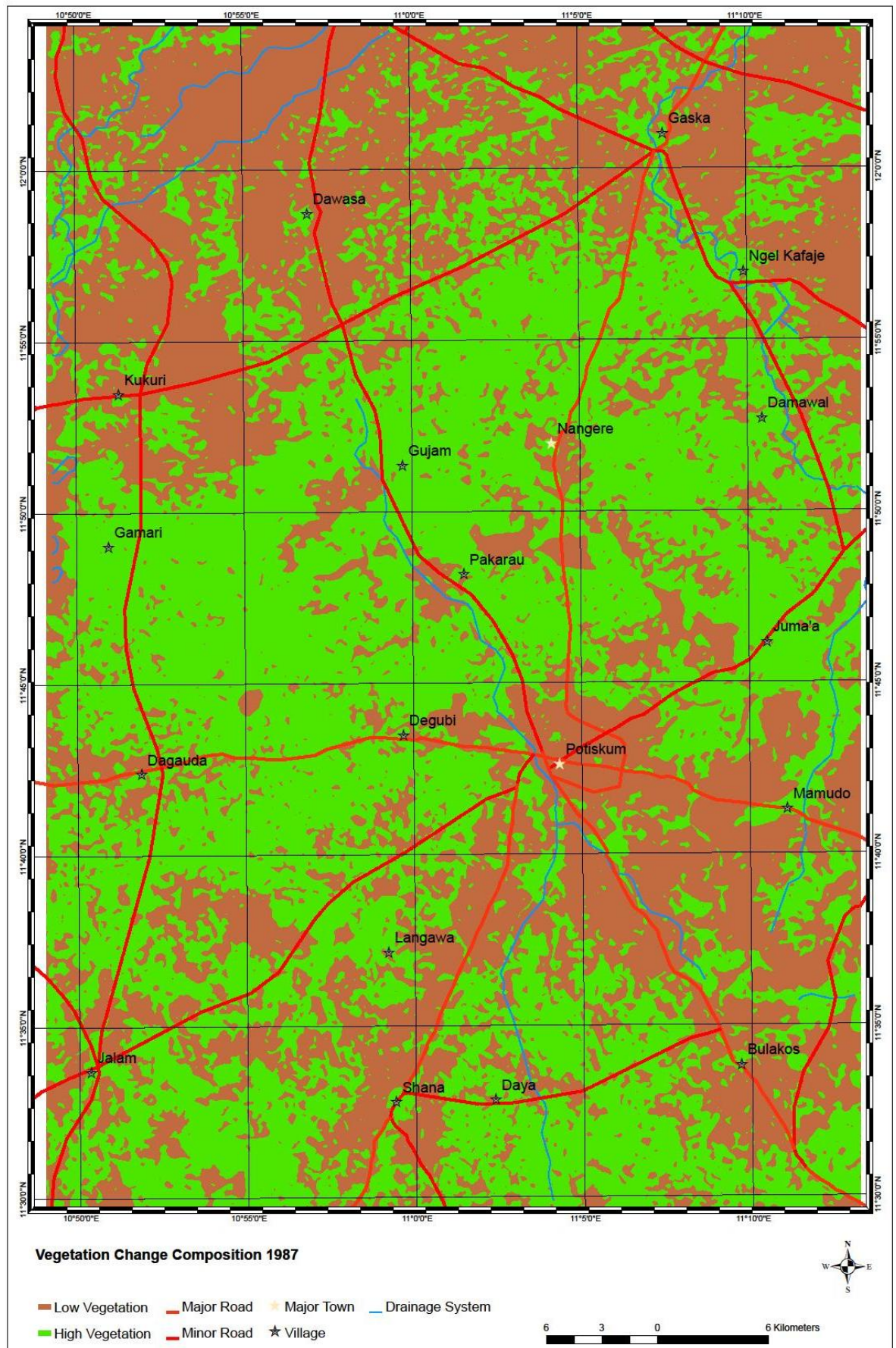


Figure 4.8: Vegetation Change Pattern in 1987

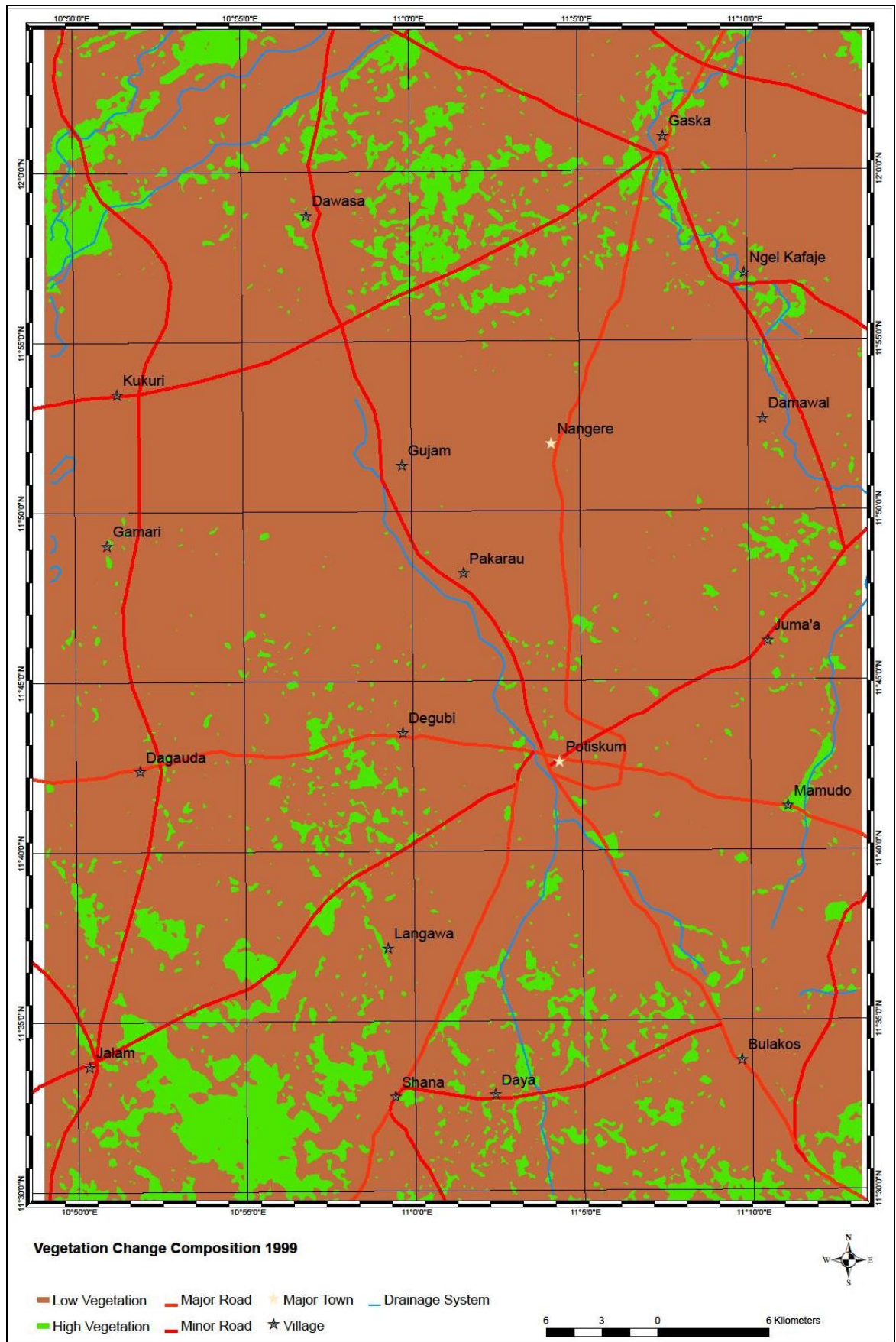


Figure 4.9: Vegetation Change Pattern in 1999

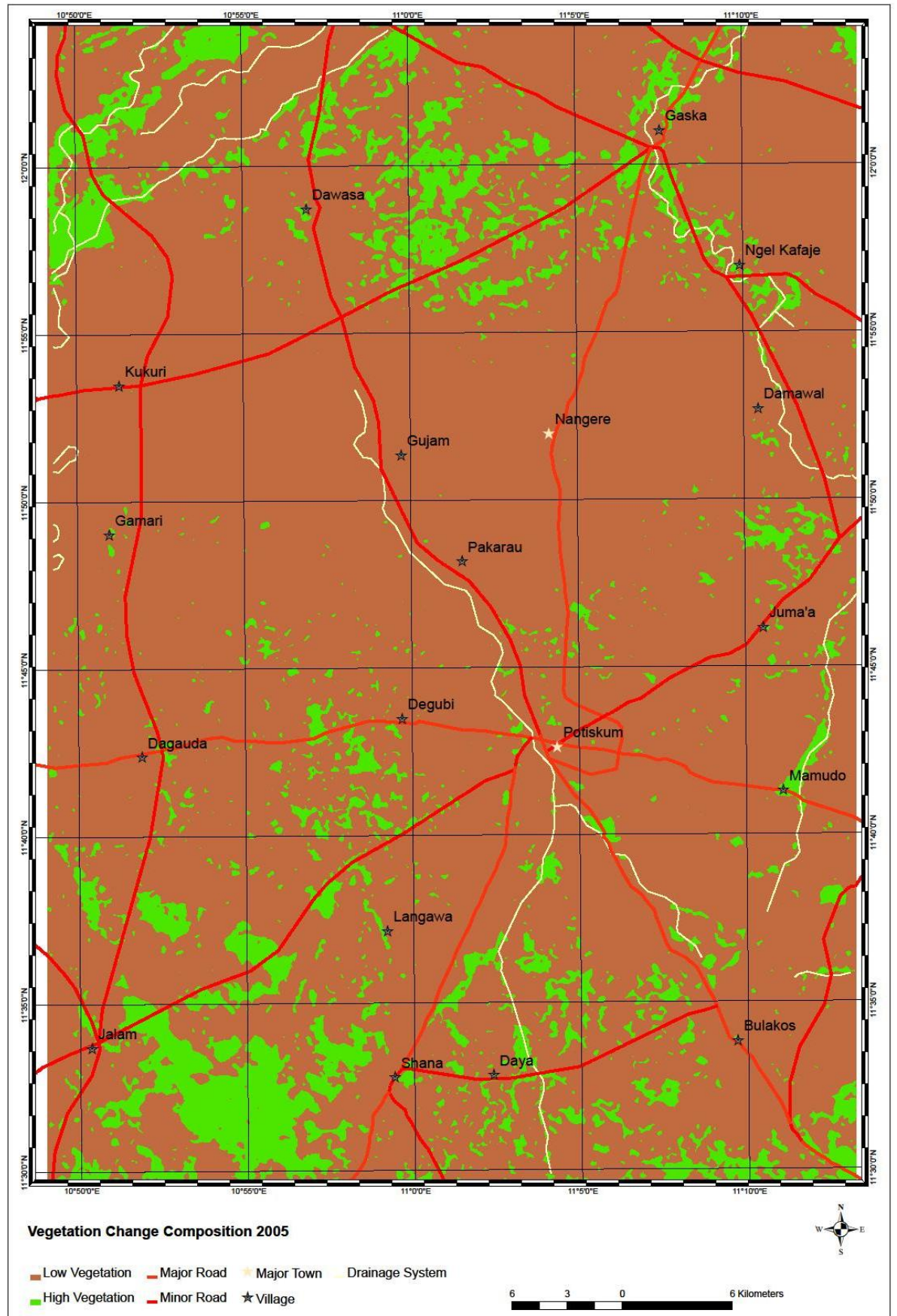


Figure 4.10: Vegetation Change Pattern in 2005

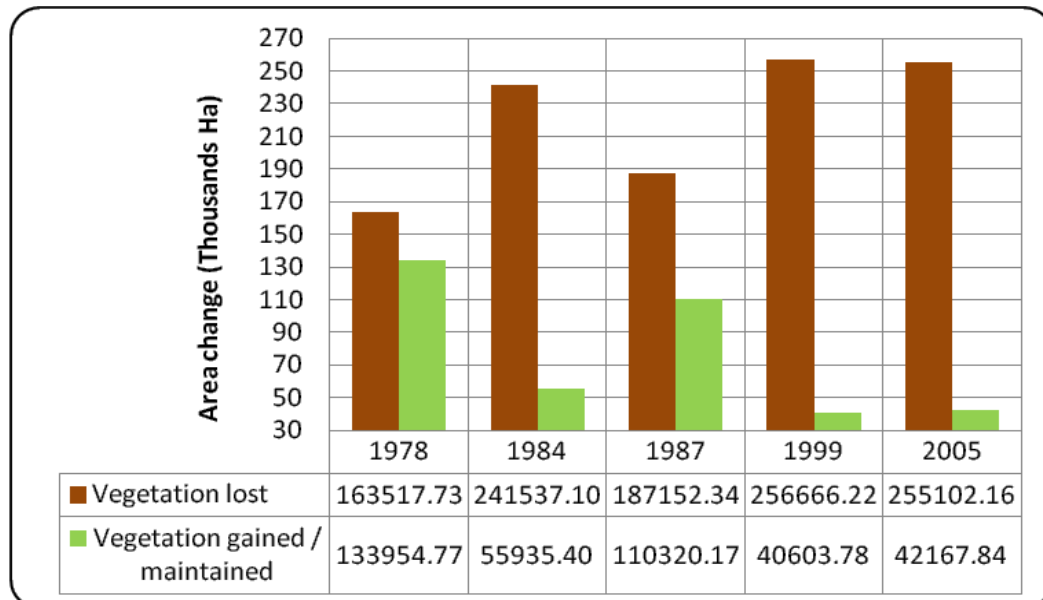


Figure 4.11: Vegetation Change Pattern in 1978-2005

The ANOVA tested the following null hypothesis: “there is no significant difference in the vegetation change patterns over the years”. The ANOVA result ($F(1, 8) = 33.64$, $P = 0.0004$ or <0.05) reject the null hypothesis and confirmed that there was a significant difference in the vegetation change patterns observed between 1978 to 2005.

4.2. Discussion of Results

The study area has a vegetation cover of about 133,954 Ha which is about 45 percent of its total area in 1978. The figure reduced to about 42,167 Ha, which is about 14 percent of the total area in 2005 (figure 4.12). This shows that there was a cumulative reduction in the vegetation of the area by about 32 percent from 1978 to 2005. However, as highlighted earlier, the vegetation change patterns oscillates from 1978 to 2005 (figure 4.12).

Conversely, it is worth noting that several factors ranging from; physical (rainfall variability), political (government policies) and socio- economic factors (population increase, demand for agricultural land and fuelwood) are assumed to be responsible for the observed change patterns. In addition, the influence of some of these factors may vary in terms of periods and locations, which are some of the reasons why certain periods have more vegetation decrease or increase compared with others. This is discussed further below.

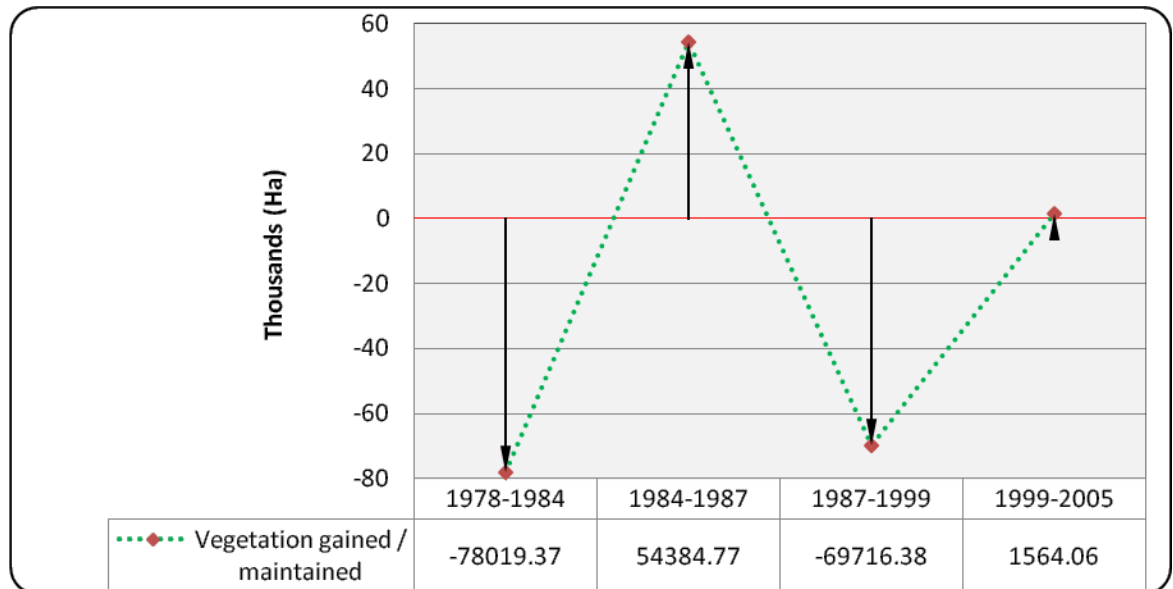


Figure 4.12: Temporal Variations in the Distribution of Vegetation Area from 1978-2005 (Ha)

4.2.1. Population Factor

Deforestation is attributed to human activities (FAO, 2010a). Therefore, population increase is among the range of possibilities that can help in explaining some of the vegetation change patterns observed. For example, Potiskum area (figure 4.13) had remained the administrative centre of the region's local authority since 1960s, this administrative role has placed the town in a favourable condition to attract more population from the surrounding villages and towns in anticipation of a better quality of life (pull factor of population migration- PRB, 2009). This has resulted in the massive expansion of the town since 1978 to cater for the needs of the new influx of people (refer to chapter 1:1.4.1 for more detail). Figure 4.13 shows how the surrounding vegetation of Potiskum town continued to reduce from 1978 to 2005. A similar situation occurred in "Sabon Garin" Nangere (the new town of Nangere) which became an administrative unit of Nangere LGA in 1996. The old town of Nangere (Nangere "Tsohuwa") still exists with little importance compared to the New Nangere which is a few kilometres away from the old town (although the main reason for the migration from old to new Nangere was flood threat in 1946).

The implications of this population increase includes amongst others the clearance of the existing vegetation for the construction of administrative institutions, social amenities, new houses and the demand for farmlands to take care of the increased population's needs. A similar finding was earlier reported by Odihi (2003) around the state capitals of Borno (Maiduguri) and Yobe (Damaturu) (the latter is the present state capital of

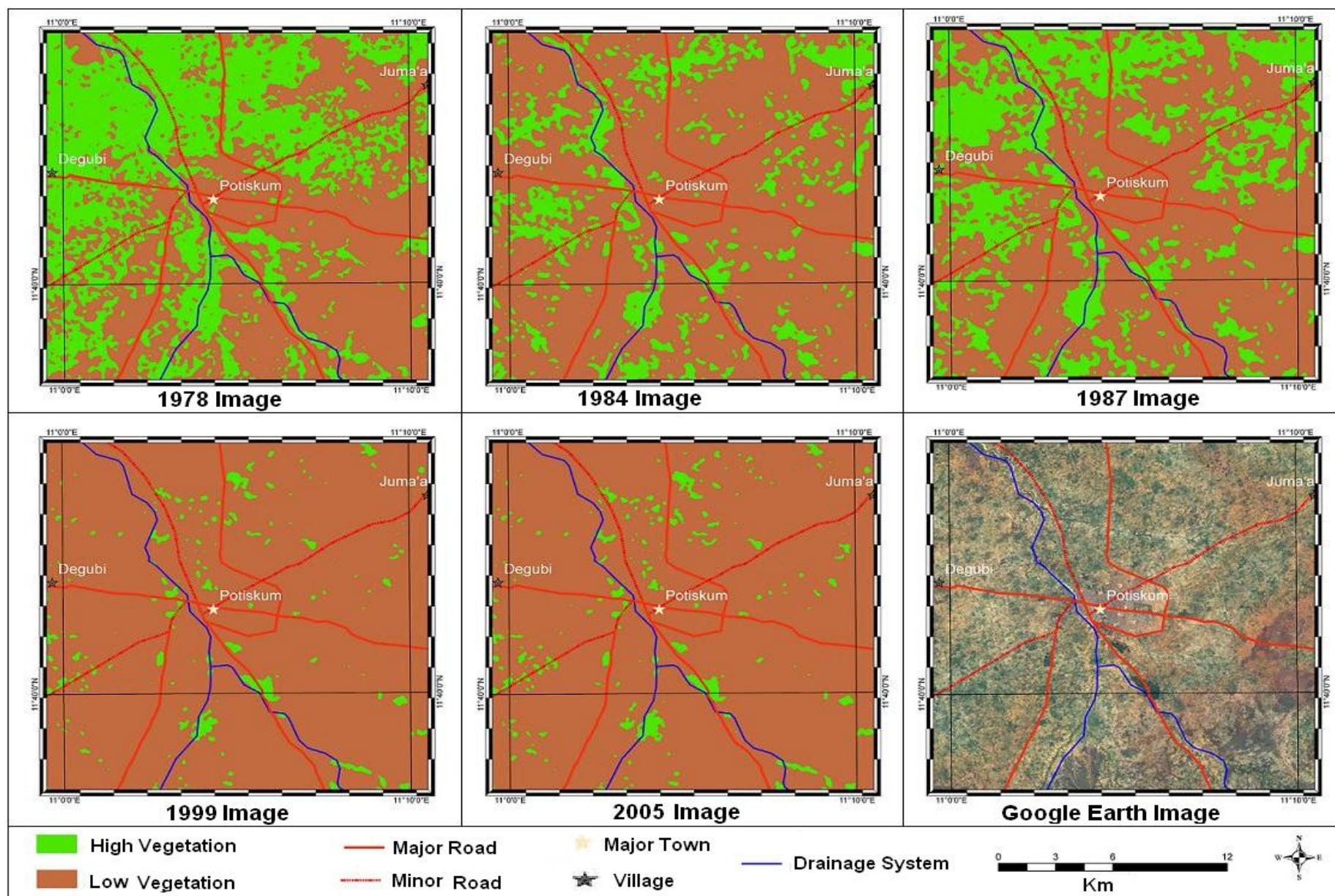


Figure 4.13: Potiskum Town and its Surrounding Vegetation from 1978 to 2005

Potiskum and Nangere, while the former was their state capital prior to 1991 when the two states were united). Meeting the increasing population's demand for food was also reported by PRB (2009) as a key challenge for the environment through deforestation, particularly in the DC (including Nigeria) where the majority of agricultural practice still remained subsistence in nature (see chapter 10: 10.4.1.4 for more detail).

4.2.2. Rainfall Factor

The vegetation change pattern observed in figures 4.6 to 4.10 did not consistently follow the trend of the rainfall pattern observed in Potiskum. The graph of the vegetation changes and rainfall variability in Potiskum presented in figure 4.14 below revealed that increased annual rainfall does not necessarily indicate an increased annual vegetation cover and neither does decreased annual rainfall reflect a decrease in vegetation. From figure 4.14, the difference in the comparative amount of annual rainfall received for example in the years of 1984 and 1987 is low which contrasted the massive reduction of vegetation in 1984 compared to the high vegetation increase in 1987. This is despite the fact that 1984 receives higher annual rainfall than 1987. Similarly, the years of 1978 and 1987 which has large vegetation all received rainfall far less than the mean compared to 1999 which receives above mean and yet witnessed vegetation decrease. Given these discrepancies observed in the pattern of vegetation and rainfall in the study area, this study initially appears to contradict the findings of Anyambaa and Tucker (2005) and Olsson et al. (2005) whose various research (using global modelling of rainfall with NDVI during rainy season) confirmed that rainfall is among the causative factors of vegetation change in the entire region. However, part of Olsson et al.'s (2005) research findings have also agreed with the results of this study specifically where they reported a consistent reduction in the NDVI of their study area during the dry season, which cannot be explained by rainfall. Even though this study did not look far beyond what was reported earlier on the possibility of rainfall influence on the vegetation, it is worth mentioning that other factors such as time lags owing to moisture storage by soil and plants (to be discussed later) may be involved in the pattern of the vegetation change observed in the study area.

Hess et al. (1995, p. 96) and Ati et al. (2009, p. 62) described the contribution of rainfall (quantity received in a particular year) in recharging the underground waters and rivers of Northern Nigeria which also shows that if there is any direct connection between the

rainfall of the study area and its vegetation during the dry season, then it could also be attributed to the soil moisture content in the periods of draught and excess rainfall. For example, the adaptation character of the xerophytic plants during the dry season⁷ may affect the vegetation health response captured by NDVI- which only records the vegetation index based on high and low leaf cover (chlorophyll). Therefore, the large decrease of vegetation in 1984 (which is bounded by annual rainfall years 1983 & 1985- see figure 4.14) matches a below mean trend of annual rainfall and the sudden increase of the vegetation in 1987 (which is bounded by annual rainfall years 1986 & 1988 that received more than the mean rainfall) will be logically explained. However, a statement by the chairman of the fuelwood vendors association in Potiskum main market during the field investigation confirmed the reduction of vegetation cover in the study area around 1984 as illustrated in figure 4.14.

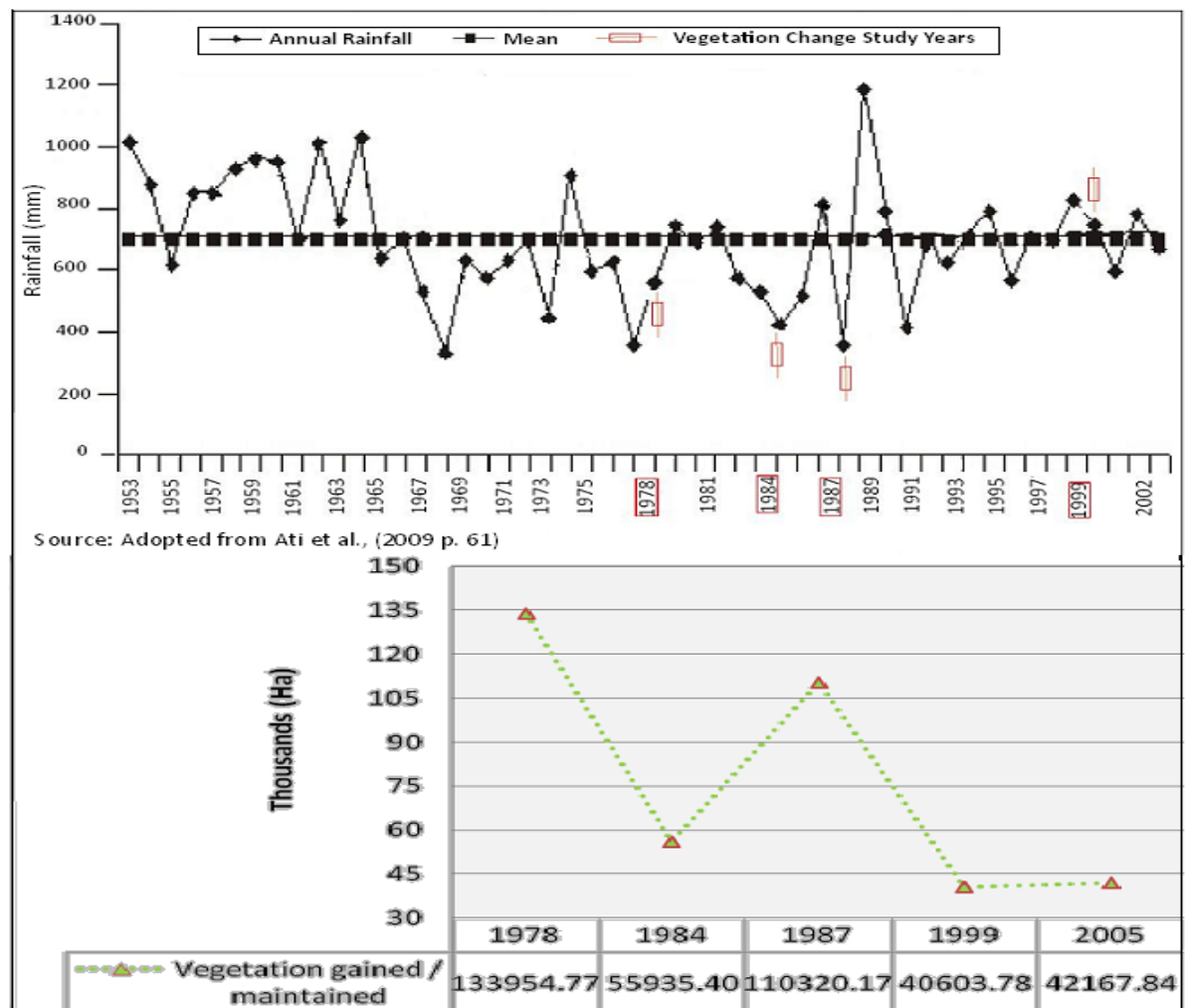


Figure 4.14: A Comparative Graph Showing the Pattern of Annual Rainfall with Vegetation Change of the Study Area

⁷ The study area's vegetation has some similar characteristics to the neighbouring northern vegetation belt of xerophytic plants- which shed their leaves in order to reduce the rate of evapo-transpiration during the dry season.

Even though, rainfall variation was not determined in this study to be the principal cause of the vegetation change observed, it should be noted that this explanation is purely provisional and therefore remains so, subject to verification or otherwise in future research.

4.2.3. Political Factors (Policies Regarding Afforestation and Agricultural Programmes)

Another potential factor which will undoubtedly have had an effect on the vegetation cover was the local and national effects of the government and some of their policies. For instance, Nigeria had eight different heads of state from 1978 to 2005, with the majority of those coming to power through military coups. These frequent and sudden changes of government are often accompanied by changing policies and political priorities. An obvious example is the case of the North East Arid Zone Development Programme (NEAZDP), which has its head office in Yobe State (Papka & Harris, n.d). NEAZDP was a joint rural development programme between the government, people and private enterprise which had the objective of assisting rural populations by improving their living standards through the sustainable use and management of the existing local environmental resources. This scheme only lasted for five years due to political uncertainty (1990-1995). The collapse of the programme was a direct result of the withdrawal of aid by the foreign collaborators when sanctions were imposed on Nigeria during General Sani Abacha's regime. The collapse of the NEAZDP resulted in the gradual abandonment of its initial initiatives towards afforestation in the arid zones of Nigeria.

Notwithstanding, most of these governments had put forward policies that at least worked during their stay in office. For example, as a result of the then Borno state government's decree during the military regime in 1986, which encouraged afforestation and discouraged deforestation by ensuring that trees were not indiscriminately exploited, people were very cautious (at that time) in the way they cut down trees. These laws were contained in the Borno State of Nigeria Gazette (1987) under the Borno state Notice No.62, captioned- "Bos. Edict No.8 of 1987 -The Felling of Trees (Control) Edict, 1986" and Bos. Edict No.7 of 1987 -The Burning of Bush Control (Amendment) Edict, 1987". Both laws emphasised tougher measures against any person caught violating them (see Box 4.2 for more detail).

Box 4.2: A Summary of a Few Sections of the Felling of Trees (Control) Edict, 1986

“Section 3: It shall be unlawful for any person to fell or destroy or cut or injure any tree in the state except with the written permission granted under section 4 of the edict.

Section 4, Sub-section 1: The commissioner or any person duly authorised by him may grant permission to any person to fell or destroy or cut or injure trees for agricultural purposes, scientific research or any other purposes.

Section 4, Sub-section 1: also provided that it shall be the duty of a farmer to leave a reasonable number of trees on his farm.

Section 6 Sub-section 1: Without prejudice to the provisions of this Edict, any person who fells or destroys a tree shall plant a tree seedling in place of the one he has felled or destroyed.

Section 7: Any person who contravenes any of the provisions of this Edict commits an offence and shall be liable to conviction—

(a) For the first offence, to a fine or to imprisonment

(b) For each subsequent offence, to imprisonment for a period not exceeding five years without the option of fine.

Section 8: Any person found committing any offence under the provision of this Edict may be arrested without warrant by a police officer, an agricultural officer, forestry officer or such other person authorised by law to arrest.

Section 9: Any person arrested under this Edict may be tried in a Magistrate Court or Area Court. “

Source: Borno State of Nigeria Gazette (1987, p A55-A56).

By the provisions of these edicts, every step of tree management was spelled out clearly in the following order: interpretation of the laws, prohibition of indiscriminate tree felling, authorised person to grant permissions of tree removal, the penalties for violating such laws, the powers given to the authorities for arresting violators of such laws and the court jurisdiction where the arrested perpetrators can be prosecuted. These edicts were effectively observed in the state until the early 1990s when the administration changed.

Other policies that have contributed to the decrease of vegetation in Nigeria include Federal Government (FG) policies such as banning the importation of wheat which is mainly produced in the dry belts regions of Nigeria (including the study area) (Odihi, 2003). This policy paved way to the clearance of more vegetation in order to open up more agricultural land for the production of the commodity. In addition, the establishment of the Directorate for Food, Roads and Rural Infrastructure (DFRRI) in 1985 which was circulated under Decree number four of 1987 (Olayiwola & Adeleye, 2005), for the purpose of providing rural infrastructure in the country were among the FG's policies that have aided the massive reduction of vegetation in the late 1980s and 1990s. For example, some of the targets of DFRRI programme were the construction of an estimated 90,000km of feeder roads, promoting rural housing, health and agriculture.

Another FG policy that has aided deforestation in Nigeria is the establishment of the National Agricultural Land Development Authority (NALDA) under Decree no. 92 by the military regime in 1992 (Akinsola & Oladele, 2004). NALDA was specifically initiated by the FG in order to increase the nation's crop production by creating more agricultural land for farmers. Although the FG's intention in establishing these policies were aimed at improving the social standards of its people, this study also agrees with Odihi (2003) that both DFRRI and NALDA have contributed a lot in decreasing the vegetation through active deforestation. For example, "during the 8 years of NALDA operation in Nigeria, more than 54,000 Ha of land were acquired within the first year of operation alone (1992 to 1993) of which 28,000 Ha were cleared and utilised. As of January 2000 when NALDA was scrapped, a total of 17,820 Ha was cultivated (Akinsola & Oladele, 2004, pp. 250-251). In Yobe state alone, more than 500 Ha of vegetated land were cleared from 1992 to 1993 as part of the NALDA project (Akinsola & Oladele, 2004). These political factors are also part of the probable reasons for the rapid decrease in the vegetation of the study area in the late 1990s. It could be part of the reason(s) why the 1999 and the 2005 resulting images (figure 4.9 & 4.10) show a huge decrease of vegetation because the cleared vegetation was not allowed to recover due to continuous farming⁸ (refer to chapter 9: 9.3.1.1).

Plate 4.1 is an example of government's efforts towards afforestation programme in the study area, which are indications that despite establishing policies that encouraged active deforestation, there were similar programmes that encouraged forest regeneration. For example, since the 1970s drought that affected the northern part of Nigeria, policies (tree planting campaigns) were put in place regarding afforestation programmes. Through such programmes, an introduced species of tree called "*azadirachta indica*" (Neem tree) thrives very well in the study area and has now become one of the most important tree species in the area in terms of use. This is because aside from the main purpose of introducing the Neem tree in the area (environmental protection- to serve as a wind break and sun shade), the local people are becoming more conscious of the tree (through tree ownership) particularly in their compounds (households) and farmlands (Odihi, 2003). Interviews conducted (see chapter 8:8.3.3.2) revealed that unlike the practice in

⁸ Note that my local observations have shown that even if the initial motive of deforestation was for farmland and rural infrastructural developments, the cleared vegetation was used as fuelwood and the area where the incident occurred (the deforestation point) was turned into a fuelwood purchasing point for road travellers.



Plate 4.1: An Example of Neem Trees Afforestation Site

(This is close to Potiskum town, Latitude 11.66209, & Longitude 11.09745 - The trees were planted in the early 1980s). Source: Author's field trip, 28th July 2010.

the past when ample vegetation cover existed within short distances from the households, the scarcity of vegetation (especially for fuelwood) has now necessitated the initiation of changes in perception towards ownership and a sense of security of their trees to supplement fuelwood shortage periods. This change in attitude was more prominent in Nangere and its surrounding villages (household's interview- refer to chapter 8). The shortage of fuelwood has also resulted to a change of attitude among some of the people, who now plant more Neem trees especially in their farmlands to complement their demand.

4.2.4 Deforestation and Agriculture

The need for an increasing number of afforestation programme campaigns in Nigeria has always been hampered by deforestation (Odihi, 2003). However, as demonstrated in chapter 2:2.2.2.1 the term deforestation has been politicised, with scholars such as Forsyth (2003, pp. 33-36) and Adams (2009, pp. 242-243) arguing that both the definition and reliable data on rates of forest loss are confusing and difficult to ascertain. They advised that forest-cover change study requires an understanding of the local political, economic, social and environmental processes at work. This suggests that avoiding a large scale generalisation about the causes of deforestation is important as earlier noted by Eckholm (1983), who also advised on the need for local-specific knowledge of the underlining cause of deforestation. Conversely, Kummer (1991) listed some of the factors responsible for deforestation in Africa as follows: Fuelwood collection; Logging; Agricultural expansion and Population pressure.

As highlighted in chapter 1:1.3 and 1.4, the study area is extensively an agrarian society (Max Lock Group Nigeria (MLGN), 1976; Sodeji, 2013 & Researcher's local knowledge). The ecology of forest clearance for agriculture is complex and very often difficult to ascertain (Adams, 2009 p. 256). While there is no doubt about the influence of both fuelwood collection (discussed later) and agricultural expansion particularly through government policies (as shown in section 4.2.3) and population pressure on the vegetation decrease of the study over the years (refer to chapter 1:1.3-1.4 & section 4.2.1), the impact of fuelwood collection was always emphasised as a significant factor of the study area's driver for deforestation since the middle of the 1970s (MLGN, 1976). For example the survey conducted by Max Lock Group Nigeria between 1973 and 1976 in the study area emphasised on the need to conserve the limited remains of the forest reserves

in the study area due to the high demand for fuelwood in the area. A similar emphasis (on the high demand of fuelwood in the study area) was discussed in the work of Bdliya (1987); Alabe (1988) and Odihi (2003).

4.2.5. Deforestation and Fuelwood Collection

Earlier studies of fuelwood consumption and deforestation in Northern Nigeria by Bdliya (1987), Cline-Cole et al. (1987), Cline-Cole et al. (1990a & b), Mortimore (1990) and Odihi (2003) have all identified the absolute reliance and demand for fuelwood as the key factor in deforestation in the northern arid zones of Nigeria. It was reported by Bdliya (1987, p.37; refer to chapter 1: 1.3) that the rate at which vegetation was being exploited for fuelwood might result in the total removal of vegetation cover of most areas including the study area by 2000. However, Bdliya's claims were unfounded in this study as earlier observed by Odihi (2003) who concluded that the population of the area still depend on the surrounding vegetation for their fuelwood requirements. Odihi's observation resulted in the questioning of Bdliya's argument which did not support the test of time and lacked any substantiated scientific evidence. Mortimore (1990), predicted that the growing fuelwood demand in the arid north of Nigeria would continue because there were no measures put in place to discourage the use of fuelwood apart from the legislatives (as explained earlier) that denied people the use of the only available resources affordable to them (see further discussions in chapters 6, 8, 9 & 10). Meanwhile, plate 4.2 is an example of fuelwood market as part of cooking energy supply options in the study area (refer to chapter 9 for more detail).

Given the current status of the country's weak infrastructure, economic development (Eroke, 2012) and lack of alternative energy sources (Maconachie et al., 2009), the price of fuelwood is far less than that of the alternative energy sources of kerosene, gas and electricity (see chapters 6 & 10 for more discussion), which is why most people depend on fuelwood as their only cooking fuel option (Casse et al., 2004 & see chapters 8 & 10 for more discussion). Additionally, with the recent withdrawal of fuel subsidy in Nigeria in January 2012, the prices of fossil fuel soared; this has the implication of committing more people to depend even more on fuelwood (see chapter 2: 2.5.1.3 & 2.5.3; & discussion of chapter 8:8.3.2.2). Therefore, in the future if the situation does not change, it is likely that the vegetation in the study area would decline further.



Plate 4.2: Pile of Fuelwood in Potiskum Market

Source: Author's field trip, 19th July 2010.

4.3. Chapter Summary, Critique and Conclusion

4.3.1. Chapter Summary

This investigation set out to map the pattern of vegetation change in the study area over time using RS to identify rates of vegetation loss. It has also suggested some of the potential causes of the observed changes. Although, emerging regional modelling of satellite measurements of the Sahelian vegetation dynamics provided new patterns of significant increase in the NDVI of the region (Anyambaa & Tucker, 2005, p.609), the interpretation of the RGB-NDVI image results reported here, revealed an irregular pattern of vegetation cover in this part of the savanna (Potiskum and environs). Periods of remarkable vegetation decrease as well as increase have been identified between 1978 and 2005. However, a complex pattern of population increase, national and local government policies and an increasing demand for fuelwood appeared to be the most important factors in explaining the vegetation changes observed. In contrast, the direct contribution of rainfall to the explanation of the vegetation change in the study area during the dry season was not found to be substantial. In particular, the lack of alternative energy sources, which lead to the quest and demand for fuelwood to meet the energy requirements of the people are thought to be a key factor in the vegetation decrease observed over the years. These results necessitate further exploration of both the national fossil fuel supplying strategy and the fuelwood situation in the study area, with a view to understand the level of their effect on the observed vegetation change patterns in more detail. The results and discussions of these studies are presented in chapters 6, 8, 9 and 10.

4.3.2. Chapter Critique

Even though this study has used Landsat satellite images obtained freely from the archives' of USGS, the results could have been improved if commercial images like SPOT were used, which could have given the result more consistency with the dates by considering the missing data periods in the 1990s caused as a result of Landsat 5 failure after launching. However, there is nothing wrong with the selection of our RS sensor or dates based on visual quality and date intervals. This was supported by Coppin and Bauer (1996, p.5) who maintained that *“for most documented vegetation change studies, the periodicity of the data acquisition seems to have been determined according to the availability of satellite data of acceptable visual quality-----, date intervals of about*

three years cycle performed best for identifying human-induced and natural canopy disturbances such as thinning, cutting, and dieback”.

4.3.3. Conclusion

Overall, the RS analysis has indicated the pattern of vegetation change in the study area from 1978 to 2005. The RGB-NDVI results also demonstrated empirically the complex nature of the vegetation change pattern of the area which has never been reported or discussed in the past using an approach similar to that utilised here. What the result failed to validate scientifically is the future pattern of the vegetation, as to whether it will continue to increase or not, given that 2005 has shown a little increase of vegetation compared to 1999. Other questions such as, whether the vegetation of the area is likely to follow a similar trend of the rainfall pattern of the area (oscillation in terms of high and low rainfall years as reported by Hess et al., 1995; Anyambaa & Tucker, 2005 & Olsson et al., 2005) even in the dry season still remained an unanswered question that this study has not been able to provide any meaningful empirical conclusion. However, as future imagery becomes available, the same RS methodology can be used to extend the current analysis for monitoring purpose. The results can then be disseminated to the relevant policy makers for necessary action. It has also been shown how low cost RS can be used successfully to study vegetation cover. Although a range of possible explanations for the observed patterns of vegetation changes have been examined, it is clear that further research is required to substantiate some of the findings. Many unanswered questions remain that will help focus future scientific debates on vegetation change in the northern arid zone of Nigeria in general, and the study area in particular.

As mentioned earlier in sections 4.2.4 - 4.2.5, the continued shortage of fossil fuel supply in Nigeria (Ogbonnikan, 2012 & Okpi & Leke, 2012) might have contributed to the massive decreased of the vegetation of the study area due to fuelwood demand (see chapter 2: 2.5.1-2.5.4 & chapter 6 for more discussion on fossil fuel distribution in Nigeria). This necessitates national exploration of fossil fuel distribution and consumption in the country, with a view to understanding the study area's situation. The next chapter (chapter 5) describes the methodology used in the study of the spatial pattern of Nigeria's fuelwood consumption and its fossil fuel supply with a view to determine how the alleged irregularities in the supply of fossil fuels in the country is influencing the use of fuelwood among the various states of the country.

Chapter 5: Methodology (Statistical Analysis of Aggregate Secondary Data: Fuelwood Versus the Other Cooking Fuel Types in Nigeria).

5.0. Introduction

This chapter describes the methodological approach to the study of the relationships between the various cooking fuel types used by households in Nigeria. An initial review of the data sources used is followed by an explanation of the quantitative analysis techniques utilised in this stage of the work. These techniques include choropleth mapping, Geographically Weighted Regression (GWR) and Principal Component Analysis (PCA).

5.1. The Role of Fuelwood Among the Cooking Fuel Types Used in Nigeria

5.1.1. Data Sources

The data for this study were obtained from secondary sources. The data were requested and obtained from the National Population Commission of Nigeria (NPC), Pipelines and Products Marketing Company (PPMC) and Nigerian National Petroleum Corporation (NNPC). It should be noted that all the data used in this chapter are official figures. The relevant organisations have explained in great detail on their various websites how such data were generated and disseminated.

Data on different cooking fuel types used by households are official census figures from the 2006 Nigerian census obtained from NPC (NPC, 2009a & NPC, 2010). The procedure for the Nigerian 2006 census is described on the NPC's website (www.Population.gov.ng). In summary, the Nigerian census is conducted every ten to fifteen years. The first national census conducted in Nigeria was in 1952. After the 1952 census, there were subsequent censuses in 1963, 1973, 1991 and 2006. All the census results throughout this period in Nigeria have been contested either by the people, regional governments or other organisations for irregularities in the conduct of the exercise. Some of these claimed irregularities arise because the State Governments (SG) obtains larger grants from the Federal Government (FG)'s monthly allocation if the population of their states increase. Therefore census figures have either been inflated or exaggerated by SG in order to benefit from additional FG grant allocations. Other irregularities are as a result of either religious or ethnic institutional differences in the country (Metz, 1991), which has seen

census figures inflated for the benefit of the relevant institutions. The results of the 2006 census data were published at the local government level which is the smallest administrative unit available for the dissemination of the 2006 national census results, despite the exercise being conducted at an Enumeration Area Level.

Census data are particularly valuable for scientific research because they have the advantage of asking everyone in-depth questions for every location in the country concurrently (Dorlin, 1993, p. 167). The answers provided can show the distinctiveness of an area, whether it is a small town or a broader region. These spatial differences act as the basis for almost all other mapping of social, economic, political, housing and medical statistics because they describes where households, jobs, voters and people are concentrated (Dorlin, 1993). For the purpose of this study, the census data were collected at the state level for easy comparison with other data sets (e.g. fossil fuel distribution) considered in this part of the study that are only produced at the state level.

The data on the distribution of fossil fuel, i.e. petroleum, kerosene and gas products were obtained from NNPC's Corporate Planning and Strategy Division (CP&S) in its 2010 Annual Statistical Bulletin. The data show the annual distribution of fossil fuels to the various states of Nigeria for 2009 in thousands of metric tons. Data on the distribution and location of all the petroleum refineries, pump stations, and depots in Nigeria were obtained from PPMC's website (PPMC, 2010).

The unreliability of official data in Nigeria highlighted earlier is one of the limitations of this study. This is because, the official data obtained cannot be verified from other sources and therefore have to be used as they stand. Problems arising from this can be illustrated using the 2006 national population census result published by the FG (News Agency of Nigeria (NAN), 2012a). The Lagos state government for example (which was declared second in terms of population in the country) argued that Kano state's population (which was declared the most populous in Nigeria) was not, in fact the highest in the country. Lagos state therefore declared itself to be the most populous, contrary to the FG's declaration (Amokeodo & Isah, 2011). Lagos state regarded the figures from the FG as being biased and politically motivated and therefore not representative of the real distribution of the country's population.

Also, the fossil fuel distribution data has its own limitations, which include among others, the unwillingness of the NNPC and PPMC to release the correct figures for the country's

fossil fuel supply and distribution in the past. This can be illustrated by the recent problems the country experienced after the FG removed the fossil fuel subsidy. This subsidy removal was challenged by the members of the parliament (Tsan & Odemwingie, 2013), who questioned the huge spending on fossil fuel subsidy in the 2011 financial year, because it was not accounted for in the national budget.

5.2. Data Organization and Interpretation

Cooking fuel types in Nigeria can be categorised into fossil fuels, which comprise kerosene and gas, and non-fossil fuel, which make up of firewood (fuelwood), charcoal, animal dung, sawdust and solar power. Electricity in the country is generated through both gas turbines and hydro (electricity). This makes it difficult to place it either in the fossil fuel or non-fossil fuel categories. Therefore, for the purpose of this study, fossil fuel, solar and electricity are referred to as modern cooking fuel types, while the non-fossil fuel excluding solar are referred to as traditional cooking fuel types. The data obtained on these two types of cooking fuels were organised using a Microsoft Office Excel worksheet and analysed using the ArcMap 10 GIS software.

5.2.1 Analysis

The energy situation in Nigeria is analysed cartographically to show the extent of spatial variations of each energy type. A map plays a vital role in depicting the spatial organisation of events. Maps have been in use as a medium of communication for many centuries (Dorlin, 1993). However, with the continuous advancement of computer graphic packages to generate maps, especially in the field of Geographical Information Systems (GIS), maps can now be used and presented in more sophisticated ways, for analysis, policy and decision making (Parker & Asencio, 2008).

Out of the numerous GIS applications available, geodemographic classification is discussed in this section because of its relevance to the analysis of census data. Geodemographics involves the fusion of demographics with geographical referenced data (Sleight, 1993), and it is defined as “*the analysis of social and economic data in a geographical context for commercial purposes relating to marketing, site selection, advertising and sales forecasting*” Johnston et al. (2000, p. 297). This definition is commercially oriented, because this is the key application area for geodemographics classification (Sleight, 1993).

Geodemographics classifications have gained popularity as an area of application in GIS (in the field of marketing and health) primarily because of their importance in classifying the socio-economic and lifestyle conditions of the population using the smallest unit of geography available (Jones, 2008 & Ojo et al., 2010). Jones (2008) uses a geodemographic classification to show the viability of the technique in exploring the causes of health inequalities in Camden, London with great success. Her analysis was based on the Output Area (OA) which is the smallest geographical unit in Britain for which census data are disseminated. Ojo et al. (2010) use geodemographic classification methods to show for the first time the viability of the method in studying the spatial distribution of population in Nigeria, using census data disseminated at Local Government area level⁹. Ojo et al.'s (2010) thematic maps show regional socio-economic differences within the country. However, their comprehensive series of maps are complex and some of their classifications are difficult to follow. For example, their description of urban land use classes based on Green Towns, Emerging Localities, Intermediate Territories, Diluted Societies, Country Dwellings, and Urban Nodes, is very difficult to interpret. For example, their map of Abuja (the Federal capital of Nigeria-especially the Abuja Municipal Area Council (AMAC)), classifies parts of the city as being either disadvantaged "urban" or "thriving diluted societies". This is questionable given that AMAC is the seat of the FG where the most influential people in the country dominate. It is therefore regarded as an expensive place to live, so it is unattractive to the poor in terms of domicile, and it lacks the characteristics of disadvantaged urban area.

Some of the problems of Ojo et al.'s maps could be a result of data generalization, which is a possible disadvantage of the geodemographics method, according to Sleight (1993). Although a geodemographic classification system has been used with a large measure of success in Nigeria (Ojo et al., 2010), a descriptive analysis of cooking fuels using choropleth mapping can be more effective, because of its simplicity in application.

Dent (1985) derives three main uses of choropleth maps as follows: 1) To ascertain an actual value associated with a geographical area; 2) To understand the geographical pattern of the mapped variable with attention to individual values, and finally; 3) To be able to query one choropleth map pattern with another concurrently. For these reasons, choropleth mapping is used in this study. The analysis conducted is illustrated in figure 5.1

⁹ Their mapping results are accessible online– <http://www.nigerianlgaclassification.com/>

below, which demonstrates how the various data were incorporated into the GIS for mapping.

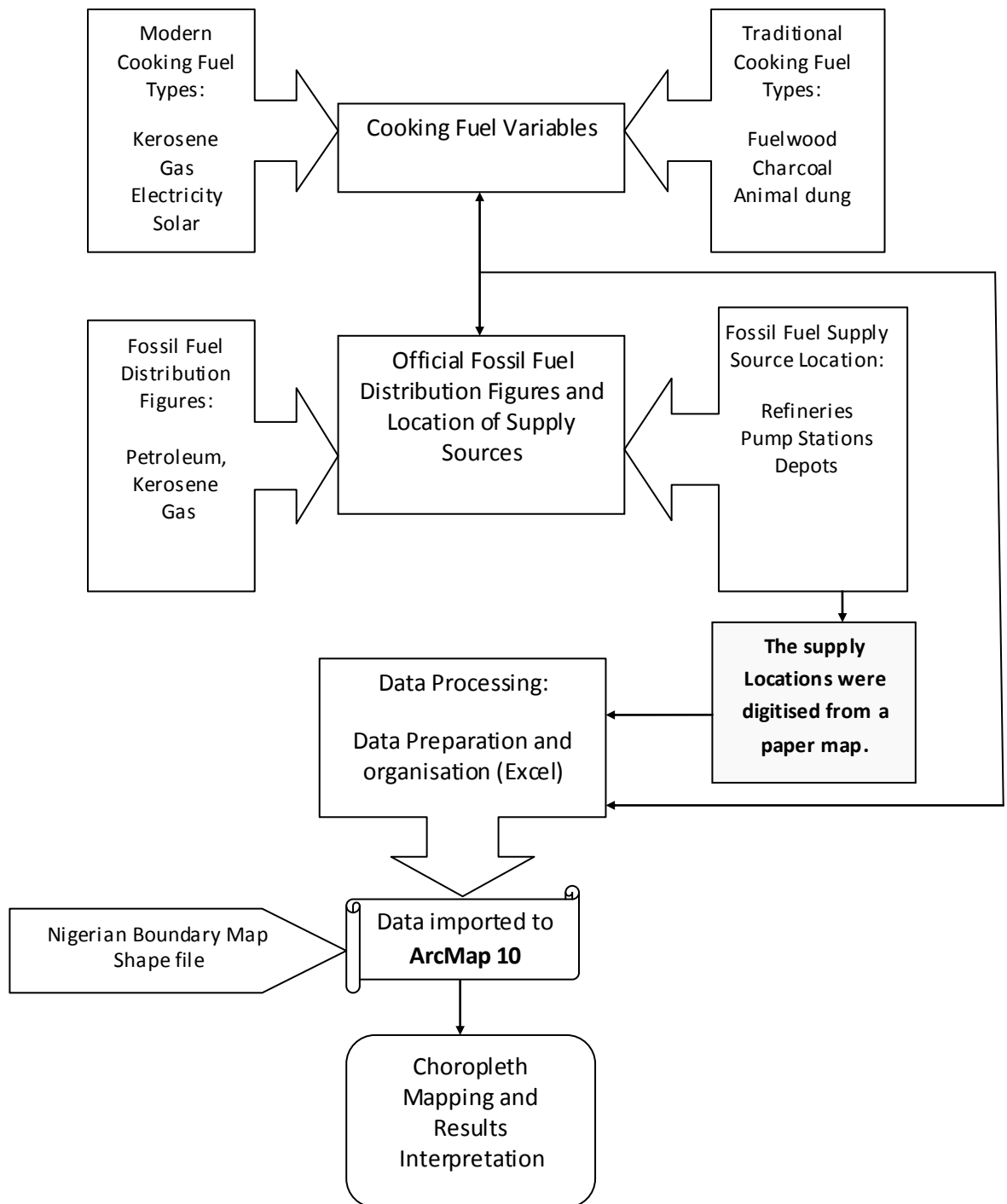


Figure 5.1: A Flow Chart Illustrating the Descriptive Analysis Conducted in this Study

The cooking fuel variables were downloaded and exported into a Microsoft Excel spreadsheet. All the data were transformed into percentages because they are easier to interpret than the raw data using the following formula:

$$\frac{\text{State (a) no.of households using specified cooking fuel}}{\text{State (a)total no.of households}} * 100 \quad \text{Equation 5.1}$$

The fossil fuel distribution data are in thousand of metric litres and were changed to percentage of distribution per state in thousand of metric litres in Microsoft Excel using the formula below.

$$\frac{\text{State (a)total supply of specified fossil fuel type}}{\text{National supply of specified fossil fuel type}} * 100 \quad \text{Equation 5.2}$$

The location points of refineries, pump stations and depots were digitised from an existing paper map obtained from the PPMC (see figure 2. 5 in chapter 2). The map was georeferenced in ArcMap 10 with an existing referenced shapefile of Nigeria.

The three data sets were organised in an excel spreadsheet (cooking fuel variables, fossil fuel distribution and the location points) which were then imported into ArcMap and joined together with the Nigerian boundary shapefile for further analysis using choropleth maps described in the next section.

5.2.2. Nigerian Cooking Fuel Atlas Using Choropleth Maps

The name choropleth is derived from the Greek words choros (area/region) and plethos (magnitude) (Tao, 2010). Choropleth maps are thematic maps that portray a single distribution of events (census tracts, counties or other areal units) and present them as homogeneous and discrete categories based on their spatial variation using gray tones or patterns ordered according to the proportion of the value or measurement of the statistical variable being displayed on the map (Johnston et al., 2000).

Choropleth maps are frequently used in demographic analysis to depict both quantitative (population density or percentages, rate of population growth etc.) and qualitative (distributions of dominant events) data types (Johnston et al., 2000). However, the reliability of a choropleth map depends on the following; homogeneity of the scale at which the data are presented, the graphic logic of its symbol and the class intervals that assign places to symbols (Wright, 1942 in Johnston et al., 2000, p. 81). While the former is dependent on the dissemination of the data set, the latter two are issues relating to data classification choice (Tobler, 1973; Cromley & Cromley, 1996 & Armstrong et al., 2003).

Choice and design considerations of choropleth maps have been topics of discussion in the cartographic community during the last few decades. The debate was mainly about the choice between classed or unclassed choropleth maps (Tobler, 1973 & Armstrong et al., 2003). Unclassed choropleth maps assign a unique colour, shade, or pattern based on the value of each unit (Tobler, 1973 & Dunn, 1987). The unclassified maps are rich in information but might not be optimal for visual discrimination of regions or values from a legend and are most often difficult to produce consistently despite being easy to generate (Dunn, 1987 & Dykes & Unwin, n.d). On the other hand, a classed choropleth map classifies areas based on their unit values and in some cases considers geographic area per class or similar classes (Dunn, 1987). Therefore, the goal of a classed map is to make sure that features with similar values are grouped in the same class.

Although classed maps tend to lose a considerable amount of information as a result of their classification method, especially if the class intervals and the classification scheme itself are not selected carefully (Dunn, 1987), classed maps are judged to be a better method than unclassified maps, because they are designed to eliminate visibility of intra-class variations and are therefore meant to delineate regional inter-class variations (Armstrong et al., 2003). Classed choropleth maps have been used in this study. The production of the choropleth maps in ArcMap 10 was achieved using the layer properties in the symbology tab, which contains the following (categories, quantities, charts and multiple attributes). The graduated colour symbols under the quantities option were deployed using three classes to;

- 1) Show the supply pattern of modern fossil fuels among the various states in Nigeria based on high, moderate and low supply.
- 2) Show the consumption pattern of the various cooking fuel types among households in Nigeria as high, moderate and low usage.

The choice of the three classes was to simplify the comparison of the resulting maps with each other so that their pattern(s) can be described or investigated further. The choice of the three classes was achieved using the classification scheme of Natural Breaks or Jenks¹⁰. The Jenks classification scheme is based on the statistical distribution of the data

¹⁰ The Jenks classification scheme is among the five default standard classification schemes in ArcMap 10 (natural breaks, quantile, equal interval, defined interval, and standard deviation) each with its own advantages and disadvantages (for more detail see - Earth Systems Research Institute's (ESRI) help in ArcMap 10 or a copy of ESRI's workbook on this website - <http://www.countyofdane.com/lcio/PDF/Symbolizing.pdf>).

(Cromley & Mrozinski, 1997), which often provides a better categorisation of class boundaries. The Jenks classification scheme identifies break points in the data set by picking the class breaks that best group similar values together and maximize the differences between classes (ArcGIS 9, 2004). Although the choice of classes and symbology is more of an art than a science, the symbols used were carefully selected and made legible using the online Brewer's colour scheme (Brewer et al., 2002) as a guide.

In addition to the choropleth mapping, another method of map visualization (stacked charts) was used in demonstrating the distribution pattern of all the cooking fuel variables in Nigeria on a single map. The stacked map summarises at a glance the pattern of usage of the various cooking fuel types among states in Nigeria. The resulting map images are presented in chapter 6.

5.3. Overview of Nigerian Spatial Interaction of Fuelwood Study Using GWR

Human activities have a strong locational component and because they vary from place to place, spatial heterogeneity is usually present in socio-economic relationships. It is possible to capture this spatial heterogeneity when modelling the structure of these relationships. Regression analysis is one of the traditional methods that are used in explaining these variations because it allows one to model, explore and examine spatial relationships and to be able to predict their outcome based on a series of observations (Field, 2009). However, there are many types of regression models available (Multivariate Regression, Logistic Regression, Ordinary Least Square Regression (OLS) and Geographically Weighted Regression (GWR)) that are used in modelling both global and local relationships. For example, Multivariate Regression, Logistic Regression and OLS are global regression methods that produce a single linear regression equation in order to summarise the global relationships between explanatory and dependent variables (Fotheringham et al., 2002). The term global relationship is applied when the relationship between the dependent variable and the independent variable (explanatory variable) is assumed to be constant across the study area at every possible location. This is one of the disadvantages of a global regression model (that is, one model fits all) when applied to spatial data (Fotheringham et al., 2002).

On the other hand, GWR which is a model first promoted by Brunsdon et al. (1996), is a local regression method which generates spatially varying parameters that express the variation in the relationships among variables. The coefficient maps which are generated from the results can be used in exploring and interpreting spatial heterogeneity (Fotheringham et al., 2002). Charlton et al. (n.d) use Analysis of Variance (ANOVA) to compare the improvements of a single overall (global) regression model with a GWR model (a local regression model) using Georgia data as a case study. They found that among the two models, the GWR model provided an improvement in terms of explaining the data. Bitter et al. (2007) also compared GWR and a global regression method to examine spatial heterogeneity in housing attribute prices in the Arizona housing market. Their result also confirmed that GWR has more explanatory power and predictive accuracy than the standard global regression model.

Even though GWR is widely used among researchers to explore spatial relationships, especially in studies of health, crime and housing, it has not previously been employed in the analysis of fuelwood consumption patterns. One popular model used in the study of fuelwood is the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) model (Drigo & Salbitano, 2008). The WISDOM model is similar to GWR in the sense that both techniques are aimed at mapping/ showing the spatial heterogeneity of events. WISDOM was conceived and promoted by FAO as a result of the collaborative efforts of FAO and the Institute of Ecology of the National University of Mexico in assessing fuelwood supply/demand situations based on local information relating to the socio-economic behaviour of people and their fuelwood usage (Drigo & Salbitano, 2008). Although both the WISDOM and GWR models provide results that show spatial heterogeneity, the two differ in their approach to data analysis. WISDOM is confined to mapping hot spots of fuelwood deficit and may not necessarily lend itself to other types of statistical analysis. In other words, it only serves as an assessment and strategic planning tool for finding priority areas for policy decisions (Drigo & Salbitano, 2008). On the other hand, GWR is a universal modelling technique that has been used in different fields as indicated above.

WISDOM, as the name implies, is a more specific kind of modelling technique that is applied to fuelwood situations in case study areas based on the requirements or steps outlined by FAO (see figure 5.2).

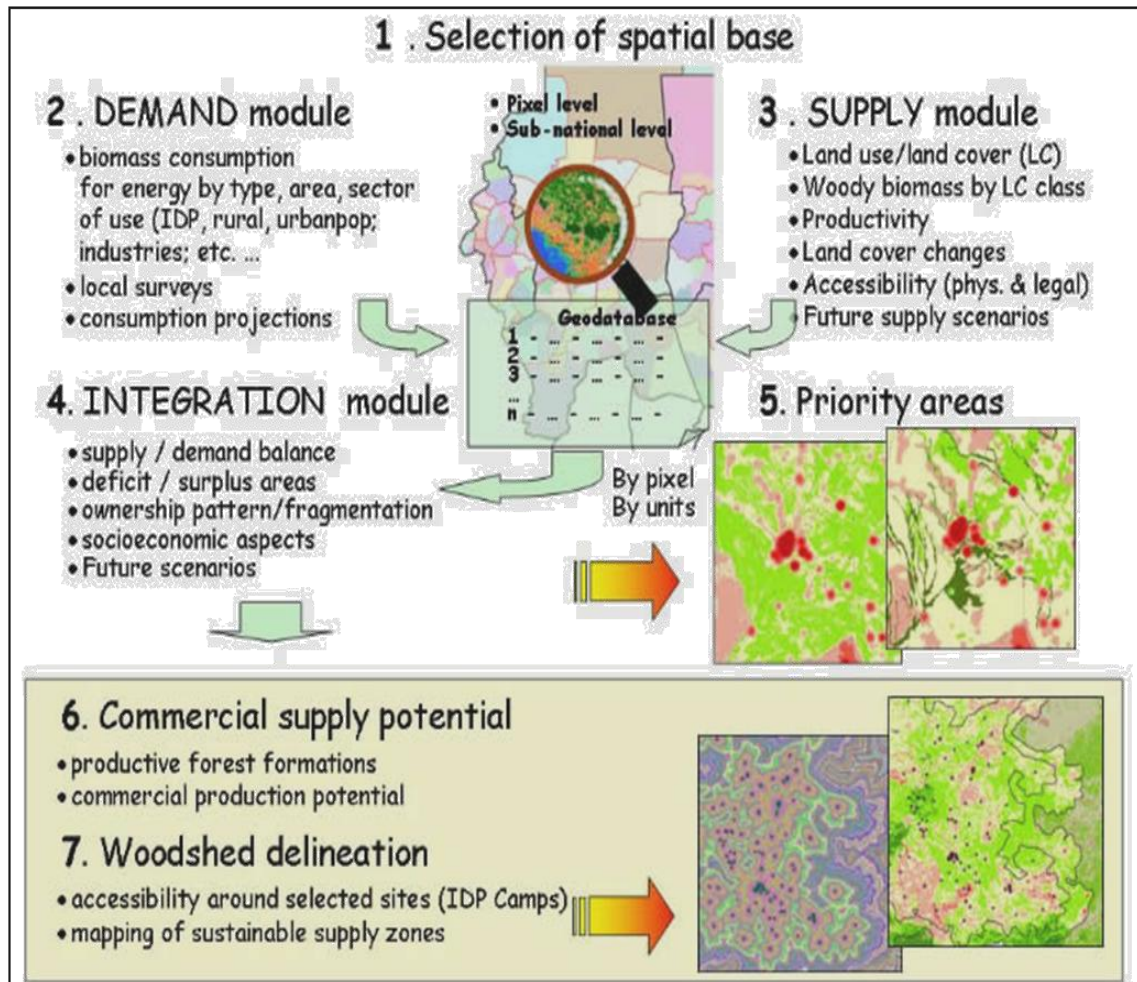


Figure 5.2: WISDOM Modelling Process

Source: Drigo and Salbitano (2008, p. 38)

The WISDOM approach, as described in figure 5.2, has a number of broad stages that are involved in the modelling process (Masera et al., 2003 & Drigo & Salbitano, 2008). Masera et al. (2003) and Drigo and Nzabanita (2011) describe the stages as follows:

- The first stage is the identification of a spatial unit of study or case study area.
- The second stage is the use of georeferenced data on the socio-economic / socio-demographic and natural resource databases of the case study within a GIS framework.
- The third stage draws together the explanatory model indicators; these relate to fuelwood demand and supply in the area
- The fourth step involves integrating all the information gathered into one model in the GIS (mapping software) for analysis and interpretation of results. Stage four can be extended to include:
 - The selection of priority areas (hot spots) that require quick policy intervention;
 - Mapping of potential “commercial” woodfuel supply centres.

- Mapping or defining the potential sustainable supply zones, based on woodfuel production potential and physical accessibility parameters.

Although these methods can be flexible in their application, they are not simple to implement, due to the amount of data that is required, which is not always easy to generate, especially in the Developing Countries (DC) like Nigeria. Also, WISDOM serves as an assessment and strategic tool using a more visual approach, while GWR has the added advantage of using a strictly quantitative approach, which can also be used to predict the future trend of events (Fotheringham et al., 2002). Hence the GWR approach has been adopted here to explore the spatial heterogeneity of fuelwood usage in Nigeria using social indicators as the explanatory variables.

5.4. Exploring Spatial Variations in Nigerian Fuelwood Usage

5.4.1. Data Sources

Data for this study were obtained from NPC, NNPC and National Bureau of Statistics (NBS). The data types and their sources are similar to those described in section 5.1.1 above. The data used for the study are briefly described in table 5.1 below. The socio-economic data provide counts of population, houses with more than three rooms (for sleeping), detached houses, huts, flats in blocks of flats, rented accommodation, educated adults (number of people over 15 years who are educated) and details of fuelwood usage. They were obtained from the 2006 Nigerian national census (NPC, 2009a & NPC, 2010). Unemployment data were obtained from NBS. Data on fossil fuel distribution was similar to the data used in section 5.1.1, which was obtained from the NNPC.

5.4.2. Data Organization and Interpretation

Despite the absence of studies of the fuelwood situation using GWR, many global regression models have been developed that show the direct relationships between socio-economic activities and energy use. Legros et al. (2009), for example, used multiple regression techniques to show that access to modern energy (electricity and all liquid and gaseous fuels used for cooking) and human development measures are significantly related. The development measures considered by Legros et al. in their model to explain the relationships included education and poverty, among others.

In a different study, Lenzen et al. (2004) analysed the energy requirements of households in Sydney using multiple regression. Their model showed that education, house type, age groups and employment were significant in explaining the energy requirements of households in Sydney. Based on the findings, this study considered the combined socio-economic variables used by Lenzen et al. (2004) and Legros et al. (2009) that have indicated significant relationships with energy access and requirements in their respective studies. This study used population, education (educated adults >15yrs), house ownership (rented houses), housing type (detached house, flats in block of flats and huts), house size (>three rooms), age (children who are <15years old), unemployment status and fossil fuel distribution in Nigeria to explain the variation in the use of fuelwood among households in the various states of Nigeria (see table 5.1).

Note: The variables in table 5.1 (data sets) were standardised by converting each of the variables to a percentage before the analysis (see equations 5.3 & 5.4 below). A Microsoft Office Excel spreadsheet was used in organising the data while SPSS statistical software and ArcMap 10 software were used in analysing the data.

$$\frac{\text{State (a) no.of households using specified cooking fuel}}{\text{State (a)total no.of households}} * 100 \quad \text{Equation 5.3}$$

$$\frac{\text{State (a) unemployed}}{\text{State (a) total population}} * 100 \quad \text{Equation 5.4}$$

5.4.3. Pre-Analysis Phase

Although the use of GWR has been found to be successful in explaining local spatial heterogeneity, it also has its shortcomings. One of the problems has been that the model can only explain the spatial variation of the explanatory variables specified in the model. Bitter et al. (2007) have highlighted the possibility of omitted variables being responsible for explaining much of the variation in the data. Charlton and Fotheringham (n.d) have suggested that the best way to circumvent this kind of problem is to explore the spatial variation of each of the explanatory variables with the dependent variable separately (visual mapping) in order to observe if there is a relationship, before deciding which variables are to be included in the model.

Table 5.1: Variable Descriptions and Summary of National Statistics

Variable Names		Variables Description	Mean	Std. Deviation	Minimum	Maximum	Sum
Population		This is the total number of people (male and female)	3795453.78	1723526.176	1406239	9401288	140431790
Unemployed		These are the people without jobs	772904.43	558329.057	188807	2594756	28597464
>Three Rooms		These are rooms under exclusive use for sleeping by all the members of the households during the census. A room used for purposes other than sleeping (that is used for sleeping purposes and as parlour or kitchen or shop or office or garage etc) was not considered as a sleeping room	276775.05	111867.778	65743	616246	10240677
Detached house		This refers to the type of residential households that are built on a separate stand or yard. This type of household is common in both urban and rural areas.	385795.78	146439.416	139708	730211	14274444
Huts		This refers to the type of residential households that are made of traditional materials (Mud, farm residuals and forest resources). These types of properties are found in rural settlements.	106597.05	96331.474	5568	332224	3944091
Flats in block of flats		This refers to a type of residential household associated with urban settlements.	74674.46	75182.051	9954	433613	2762955
Rented		This is the form of ownership or tenancy under which the household occupies the building/compound. These types of households are more common in urban than rural settlements. In some ways, it is a measure of living standard (development).	173169.11	276320.679	14281	1663621	6407257
No. of people over 15 years who are educated (Educated> 15yrs)		Literacy was defined in the 2006 Census as the ability to 'both read and write with understanding in any language'. An educated person is therefore, one who can read and write with understanding of a short and simple statement about his daily life in any language (local or foreign).	1549970.05	978961.197	430503	5511071	57348892
No. of children who are under 15 years (Children<15yrs)		This is the population of children aged less than 15 years. This age group constitute the highest number of most developing countries demographic structures.	1582165.97	751653.557	535526	4422452	58540141
Fuelwood		This is the main source of fuel for the preparation of meals by the households. (The number of households using fuelwood)	434149.51	172480.856	105593	950749	16063532

Another issue with the GWR model is that spatial variations in a relationship may simply be caused by random sampling variations in the study area (Charlton et al., n.d). And because the GWR model is only interested in the relatively large variations in the parameter estimates that are not likely to be caused by sampling variation alone, the random sampling variation effects, if not spotted and addressed prior to model building, may affect the final result. It is therefore recommended that the effect of random sampling variations “if any” should be recognised and appraised if one is to find genuine spatial non-stationarity of events in the final result (Charlton et al., n.d).

To do this, Charlton and Fotheringham (n.d) suggested that before commencing regression analysis with the variables proposed in the model, there is the need to conduct some statistical testing in order to evaluate the character of each variable. For this reason therefore, a simple correlation and scatter plot were used to diagnose the variables proposed in the model (note that all the variables were transformed to percentages before the commencement of the analyses).

The result of the correlation analysis (see figure 5.3) reveals some initial associations. The associations of all the variables with firewood usage are in the expected direction. As anticipated, the use of fuelwood will increase as a result of the following situations; when population increases; when there is high unemployment; when there are numerous households with many rooms; and when the area is rural (huts). It is also expected that the use of fuelwood will decrease in urban areas, where houses are rented and living space is mostly restricted to block of flats (all these are further investigated using OLS regression— see chapter 6: 6.4.1.2).

While most of the variables associations are in the expected directions with fuelwood usage, some exhibit multicollinearity (i.e. the variables are highly inter-correlated). Results from table 5.2 reveal that multicollinearity exists between the detached house and >three rooms variables (0.71), between rented accommodation and flats in block of flats (0.85), between educated>15yrs and flats in block of flats (0.83) and between educated>15yrs and rented accommodation (0.70).

Given these findings of multicollinearity among the model variables, there is the need to explore them further in order to exclude some of them from the model or simplify them (by grouping them together). Through this procedure, a better model can be achieved while avoiding the complexities of including two or more variables that are explaining

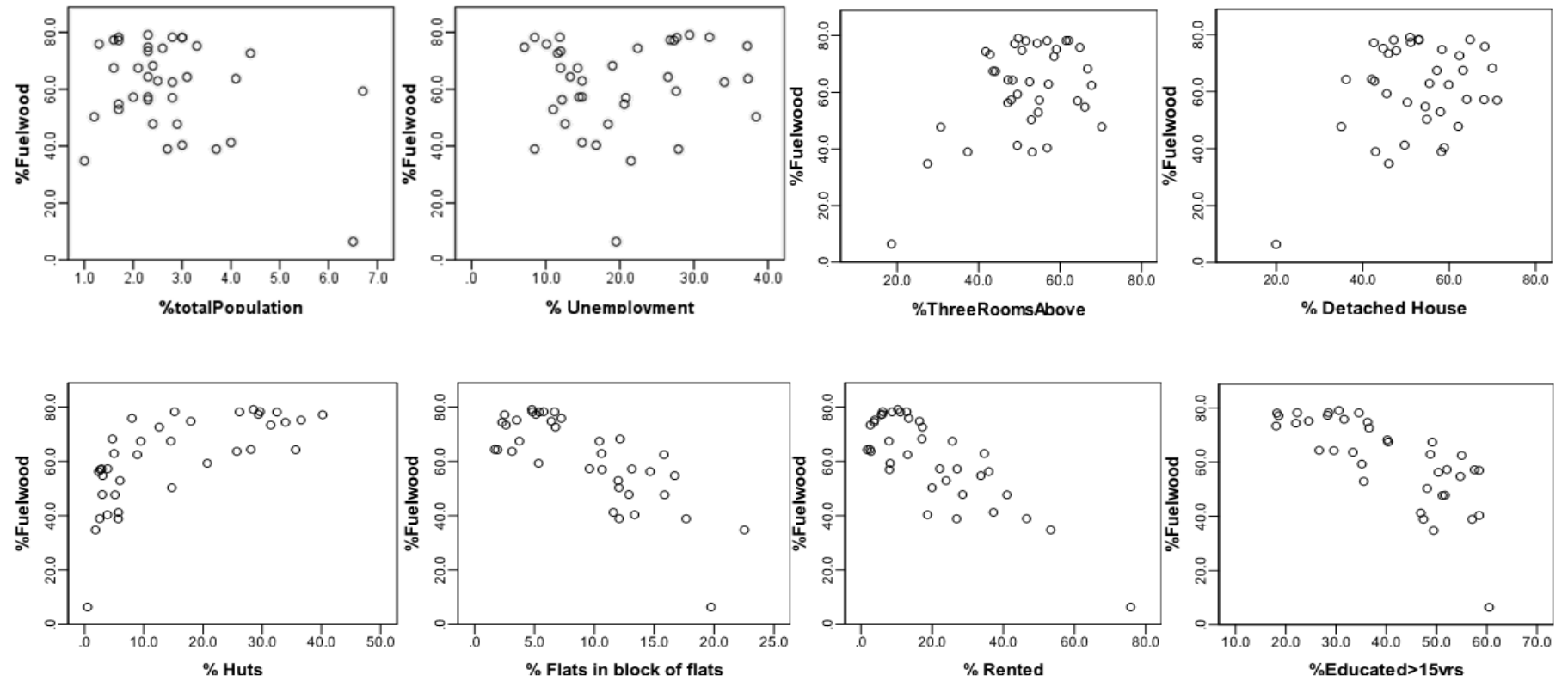


Figure 5.3: Regression Plots showing the Relationship between Fuelwood and the Model Variables

Table 5.2: Correlation Coefficients

Variables	%Fuelwood	%Total pop	% >Three Rooms	% Unemployment	% Detached House	% Huts	% Flats in block of flats	% Rented
%Total pop	-.345							
%>Three Rooms Above	.473	-.224						
% Unemployment	.072	.149	.086					
% Detached House	.324	-.413	.712	-.319				
% Huts	.684	-.028	.024	.470	-.339			
% Flats in block of flats	-.799	.035	-.195	-.144	.020	-.842		
% Rented	-.826	.184	-.508	-.288	-.280	-.738	.852	
%Educated>15yrs	-.787	.139	-.087	-.222	.157	-.879	.827	.702

similar things. This procedure according to Charlton and Fotheringham (n.d) is cumbersome and one of the reasons why GWR model building is more of an art than a science. However, because of the difficulty of determining which variables should be excluded from the model due to multicollinearity, a Principal Component Analysis (PCA) was used to simplify the variables into a smaller number of independent dimensions of variation (Brunsdon et al., 2007).

5.4.3.1. Principal Component Analysis (PCA)

PCA attempts to explain a set of data in terms of a smaller number of dimensions by selecting those components that may explain as much of the variance in the sample as possible (Hutcheson & Sofroniou, 1999 & Landau & Everitt, 2004). In PCA, linear components of the observed variables are formed, where the first principal component is the weighted linear combination of the variables that accounts for the largest amount of the variance in the sample. The subsequent principal components which are uncorrelated with each other will provide the maximum amount of the remaining total variation in the data that are formed from the residuals of the correlations left over from the previous PCA after each component has been identified (Landau & Everitt, 2004). The PCA was undertaken in SPSS using the following equations:

$$\begin{aligned} \text{Principal component 1} = & \beta_{1(1)}\text{ThreeAboveRooms} + \beta_{2(1)}\text{Unemployed} + \beta_{3(1)}\text{DetachedHouse} \\ & + \beta_{4(1)}\text{Huts} + \beta_{5(1)}\text{Flatsinblockofflats} + \beta_{6(1)}\text{Rented} + \beta_{7(1)}\text{Children<15yrs} \\ & + \beta_{8(1)}\text{Educated>15yrs} + \beta_{9(1)}\text{Fossil Fuel Supply}. \end{aligned} \quad \text{Equation 5.3}$$

$$\begin{aligned} \text{Principal component 2} = & \beta_{1(2)}\text{ThreeAboveRooms} + \beta_{2(2)}\text{Unemployed} + \beta_{3(2)}\text{DetachedHouse} \\ & + \beta_{4(2)}\text{Huts} + \beta_{5(2)}\text{Flatsinblockofflats} + \beta_{6(2)}\text{Rented} + \beta_{7(2)}\text{Children<15yrs} \\ & + \beta_{8(2)}\text{Educated>15yrs} + \beta_{9(2)}\text{Fossil Fuel Supply}. \end{aligned} \quad \text{Equation 5.4}$$

$$\begin{aligned} \text{Principal component 3} = & \beta_{1(3)}\text{ThreeAboveRooms} + \beta_{2(3)}\text{Unemployed} + \beta_{3(3)}\text{DetachedHouse} \\ & + \beta_{4(3)}\text{Huts} + \beta_{5(3)}\text{Flatsinblockofflats} + \beta_{6(3)}\text{Rented} + \beta_{7(3)}\text{Children<15yrs} + \beta_{8(3)}\text{Educated>15yrs} \\ & + \beta_{9(3)}\text{Fossil Fuel Supply}. \end{aligned} \quad \text{Equation 5.5}$$

Using the PCA equations above, the original data variables (table 5.2) are grouped into three principal components, which are fed into the GWR model. The next chapter presents the results of the GWR analysis.

Chapter 6: Exploring the Nigerian Cooking Fuel Situation Using GIS and GWR

6.1. Introduction

An initial literature investigation of cooking fuel consumption in Northern Nigeria revealed some bias in favour of the traditional fuelwood, which the majority of the households related to the lack of an alternative energy source (i.e. the precarious nature of fossil fuel supply). This initiated a wider exploration of cooking fuel supply and consumption at the national scale, in order to understand the spatial patterns of fossil fuel distribution in Nigeria. Using the national census data obtained from National Population Commission of Nigeria (NPC) and fossil fuel distribution data obtained from Nigerian National Petroleum Corporation (NNPC) and its subsidiaries (see chapter 5), a new spatial database has been created and used to explore cooking fuel usage. As previously noted, the database categorises the different cooking fuels in Nigeria into “Modern fuels”; which consist of kerosene, gas, solar and electricity; and “Traditional fuels”; which consist of firewood/fuelwood, charcoal and animal dung (see chapter 5 : 5.1 – 5.4.1)¹¹.

This chapter presents the results of an analysis of the spatial pattern of cooking fuel energy utilisation in Nigeria, using this new spatial database. The supply patterns of fossil fuels are also examined, together with variations in the use of these fuels among households in the 36 states of Nigeria (and Abuja the Federal capital Territory (FCT)).

6.2. The Consumption Pattern of Cooking Fuel in Nigeria

Nigeria is endowed with many types of energy resources. If these were fully harnessed, utilised and supplied to households, the majority of the latter would be willing to switch over to their use from fuelwood, particularly for cooking (refer to chapter 8: 8.1j).

¹¹ Note that Nigeria’s crude oil is primarily exploited in the southern part of the country (Niger Delta- south-south and a few other southern states) (see chapter 2: 2.5 for more detail). However, recently the NNPC and some northern State Governments (SG) in Nigeria have declared the potential of crude oil and gas deposits in some parts of the northern region of the country (BBC Hausa, 2012a; Sweet crude, 2012 & Imam, 2013). The FG government has already committed itself towards the exploration of crude oil in the northern region. This was highlighted in a Nigerian newspaper; Nigeria Good News (2013) which quoted the Chairman of the Northern Nigerian Economic Summit and former minister, Professor Jerry Gana, saying that *“the federal government has provided the sum of \$100 million in its 2013 budget to facilitate the exploration activities for oil and gas in the northern region.... The money would be used for continuous assessment of hydrocarbon resource potentialities in the basins of the region”*. While the country awaits the realisation of the latter claim of oil exploration in some states of the northern region, the supply of all fossil fuel is currently from the southern region of the country.

Analysis of usage of different cooking fuel types among households (figure 6.1), revealed that more fuelwood is being used for cooking than any other fuel type. Out of the 28,197,085 households in Nigeria (NPC, 2010), only Lagos state uses less fuelwood than other fuel types, while about 30% of households in each of the remaining 36 states (including Abuja) primarily use fuelwood for their cooking. Similarly, solar energy is the least popular form of energy. It is only used for cooking by 41,786 households in the country.

Fuelwood use varies across the different states. However, figure 6.1 shows the northern states to be the largest users of fuelwood. On the other hand, kerosene (modern fuel) which is the second most important fuel after fuelwood (in terms of usage among households) dominates the southern part of the country, particularly in the states of Lagos, Oyo, Rivers and Ogun where the use of kerosene surpasses any other cooking fuel type. For example, out of the 2,195,842 households in Lagos State, about 1,771,100 households (more than 80%) solely use Kerosene for their cooking. In contrast, more than 70% of households in most northern states use more fuelwood than any other cooking fuel type (figure 6.2). Several states in the southern part of Nigeria and Abuja have less than 40% of their households using fuelwood (see figure 6.2) and Lagos state has the lowest percentage of all.

6.3. Fossil Fuel Distribution in Nigeria

The zonal distribution of fossil fuel in Nigeria is lopsided (see figures 6.3 and 6.4), because some areas receive more supply than others. As observed from figure 6.4, the North-East and South-East zones receive the lowest supply.

In terms of the percentage share of the total fossil fuel supply in Nigeria, the South-West receives the highest at 41.54%, followed by the South-South region with 23.87%. The North-Central receives 16.64%, while the North-West which has the highest population in the country (among all the zones) only receives 5.92% of the total supply. The FCT, with the smallest population, receives 4.91%, which is only 1% less than the supply of North-West and slightly higher than the supply of North-East and South-East, which receive 4.35% and 2.77% of the total supply respectively. These variations in the supply patterns of fossil fuels can now be further disaggregated by modern cooking fuel type.

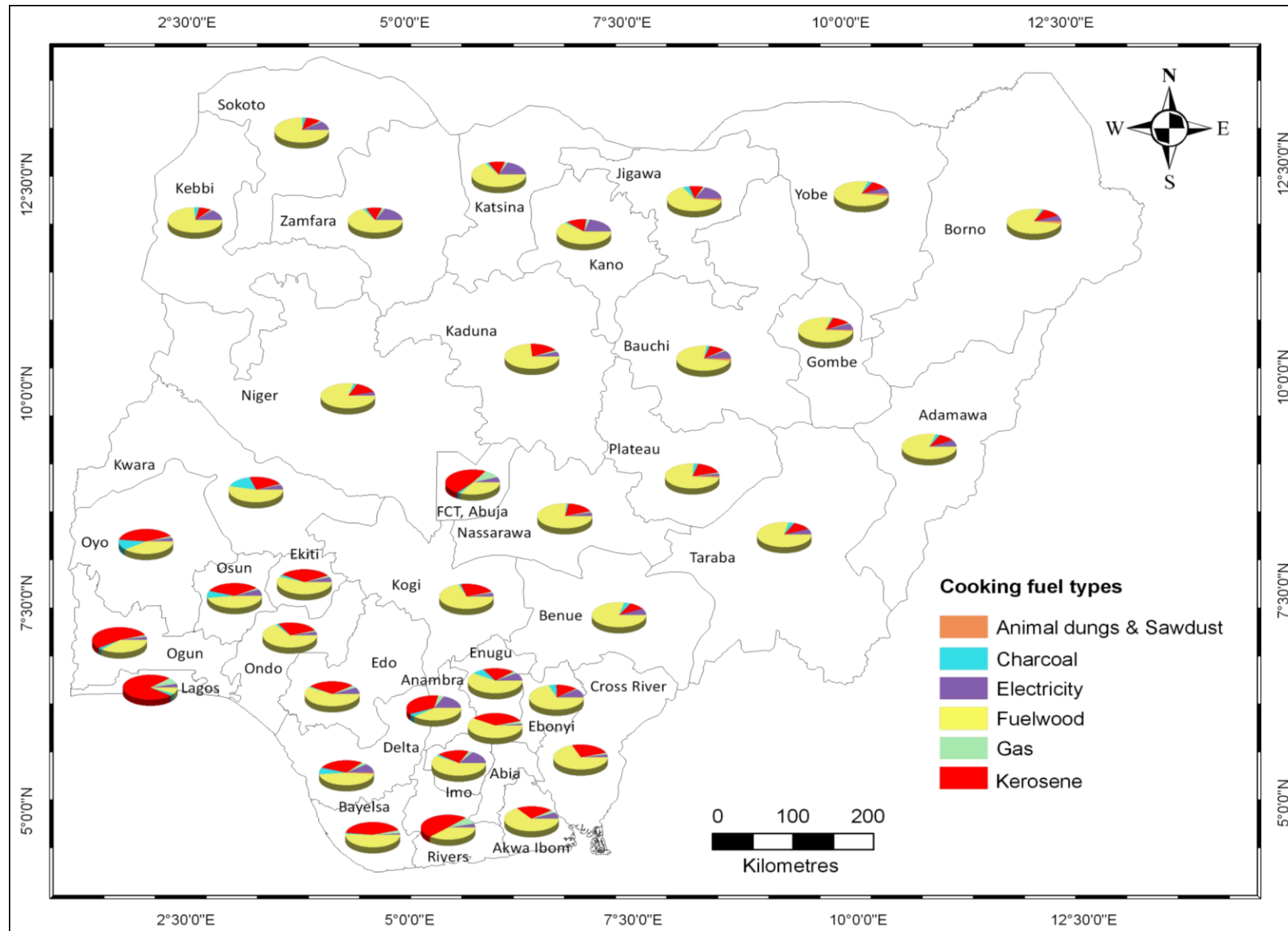


Figure 6.1: The Proportion of Cooking Fuel Types Used Among Households in Nigeria

N.B. The symbols are not proportional to the population of each state

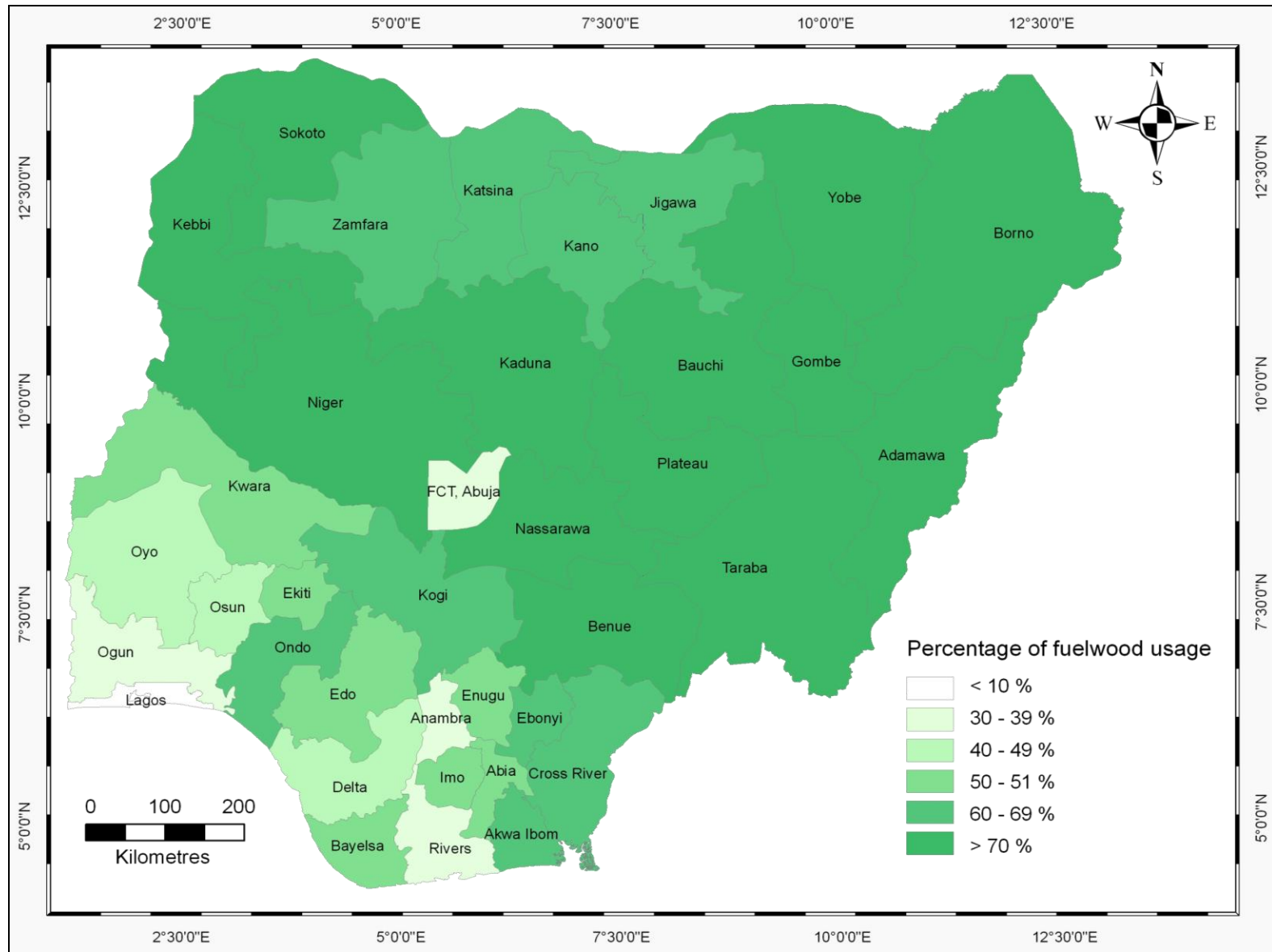


Figure 6.2: Percentage of Households Using Fuelwood for their Cooking In the Various States of Nigeria

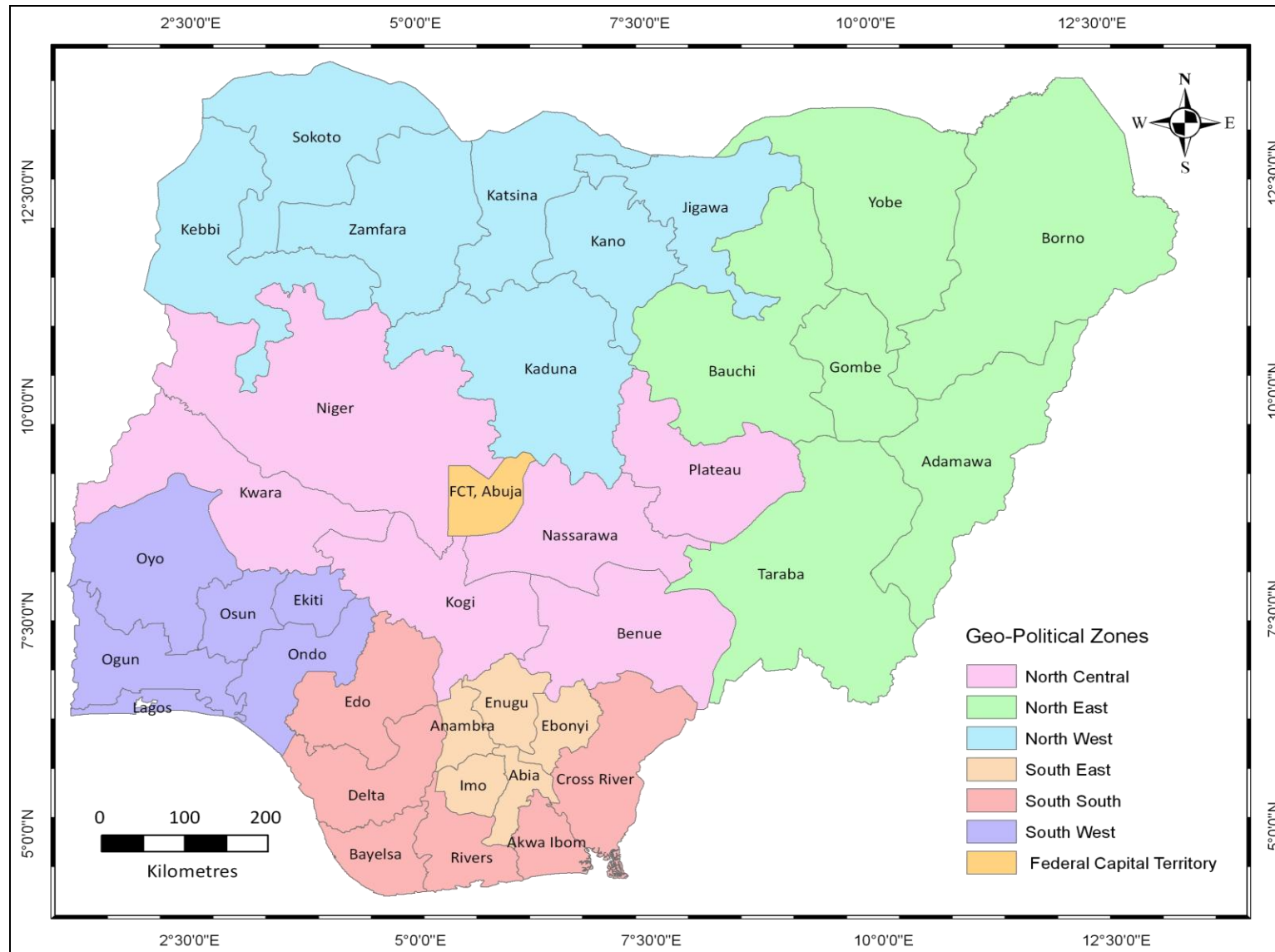


Figure 6.3: Distribution of Zones in Nigeria

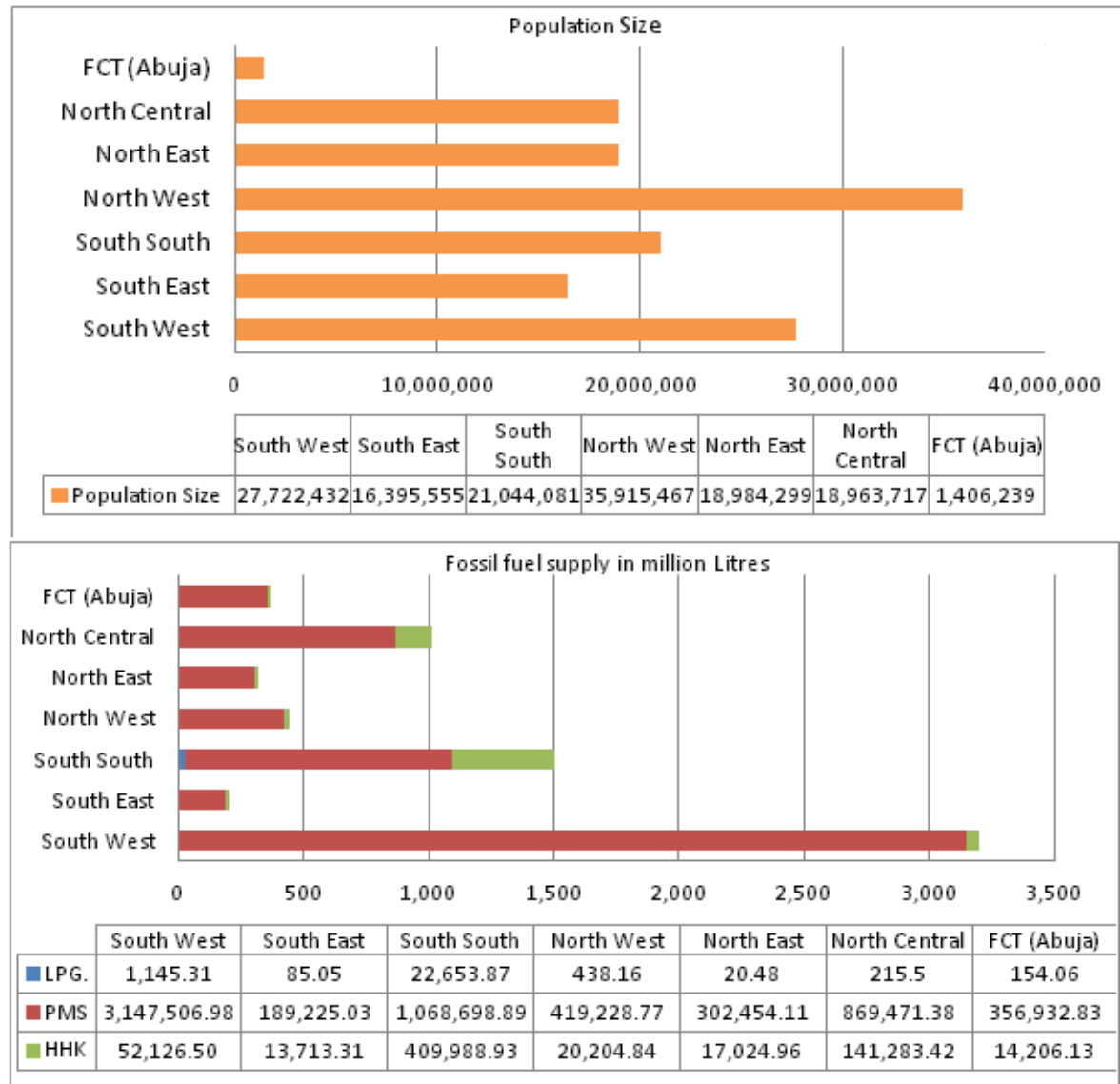


Figure 6.4: Nigerian Zonal Population Size and Fossil Fuel Distribution in 2010 ('000 litres)

6.3.1. Household Kerosene (HHK)

The spatial distribution of Household Kerosene (HHK) between the various states (figure 6.5), shows that only Kaduna state in the north; Lagos, Edo, Delta and Rivers states all in the south and the FCT receive a high supply of HHK. It is again evident from figure 6.4 that the supply of HHK in the country is insufficient, given that the great majority of the states receive a very limited supply of the commodity (figure 6.5).

The disparity in the supply pattern of HHK matches the differences in the consumption pattern of fuelwood in the various states (areas with a lower supply of modern fuel are using a greater amount of fuelwood and vice versa). However, a few states were observed to be consuming large amount of fuelwood, despite also receiving a high or moderate supply of HHK. For example, Kaduna state in the north receives a good deal of

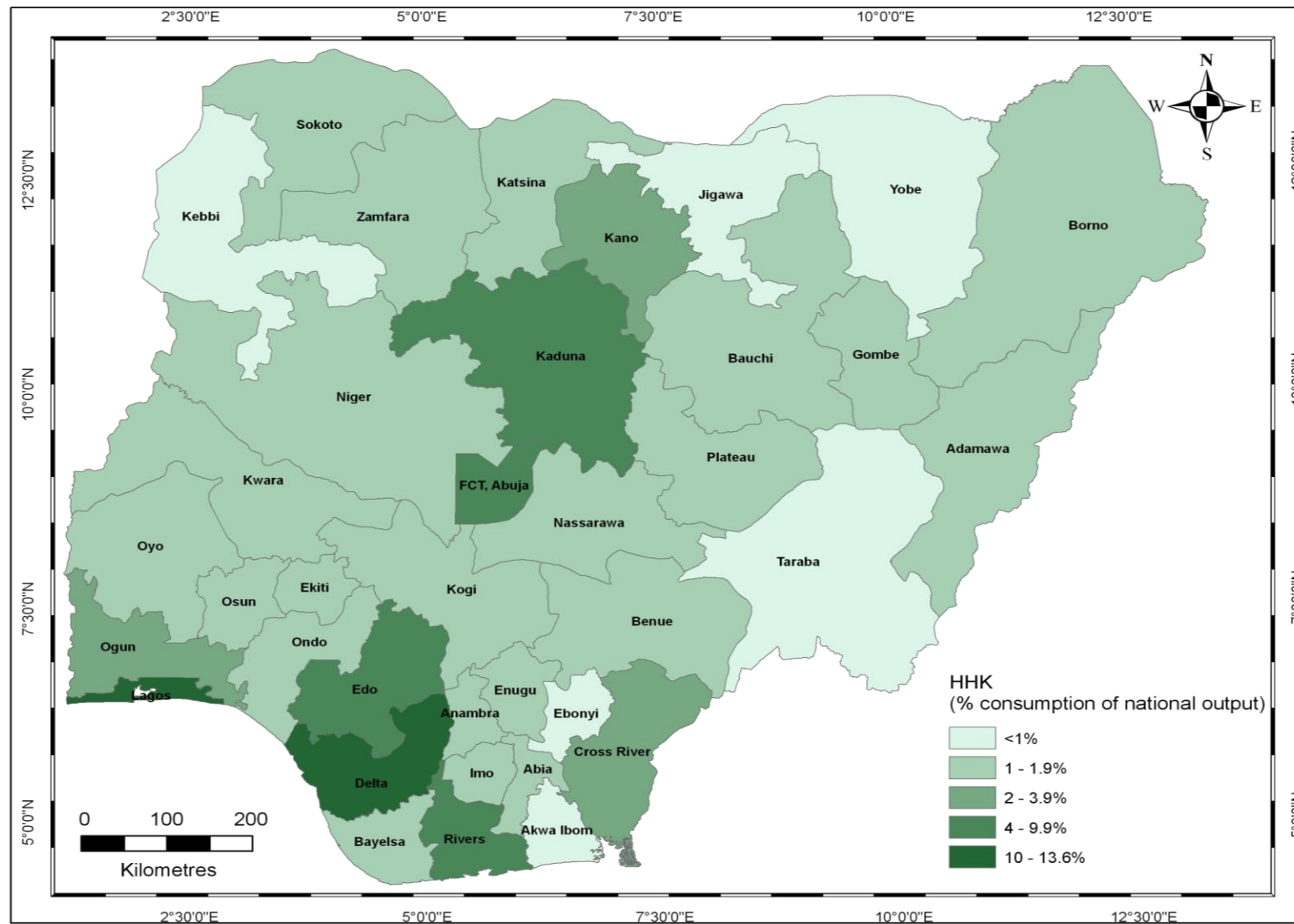


Figure 6.5: Household Kerosene (HHK) Distribution by States in 2010

HHK (about 3 litres per person), but more than 70% of its households use fuelwood. In contrast, states such as Anambra in the south, receive a more limited amount of HHK (about 0.8 litres per person) and yet less than 40% of its households use fuelwood. Despite these apparent inconsistencies in a few states, others such as Rivers and Lagos in the south and the FCT, which all receive a large supply of HHK (3.3, 3.0 and 10.1 litres per person respectively), appear to be using correspondingly less fuelwood. Likewise, the majority of the northern states, which receive a limited supply of HHK (less than 1 litre per person), depend largely on the traditional fuelwood.

6.3.2. Liquefied Petroleum Gas (LPG)

As shown in figure 6.6, the supply of Liquefied Petroleum Gas (LPG) in the northern part of Nigeria is high in Kano state and moderate in Kaduna state. Despite the high and moderate supply of LPG in these states, more than 65% of their households depend on fuelwood for their cooking. In contrast, Anambra, Delta and Ogun states in the south receive a low supply of LPG, while about 40% of their households use fuelwood. In Rivers and Lagos states in the south and FCT, LPG supplies are ample and they are among the lowest users of fuelwood in the country. This is not surprising because these states are the most affluent in the country, each with various key functions (Lagos as the commercial centre of Nigeria; Rivers as the headquarters of the oil companies and FCT the as the seat of cultural government). Figure 6.6 suggests some irregularities in the supply of LPG, which seem to be confined to few states.

6.3.3. Premium Motor Spirit (PMS)

Although Premium Motor Spirit (PMS) is not directly used as cooking fuel in Nigeria, its relevance to the procurement process for fuelwood cannot be overlooked¹². PMS supply affects the life style of the people because the higher its price, the higher the cost of fuelwood and all other commodities, since the major form of goods delivery within the

¹² PMS has relevance in terms of fuelling the vehicles that convey goods in the country and fuelling household power generators (small sets of generators) that the majority of households in Nigeria use in supplying temporary electricity in their homes (Adenikinju, 2003).

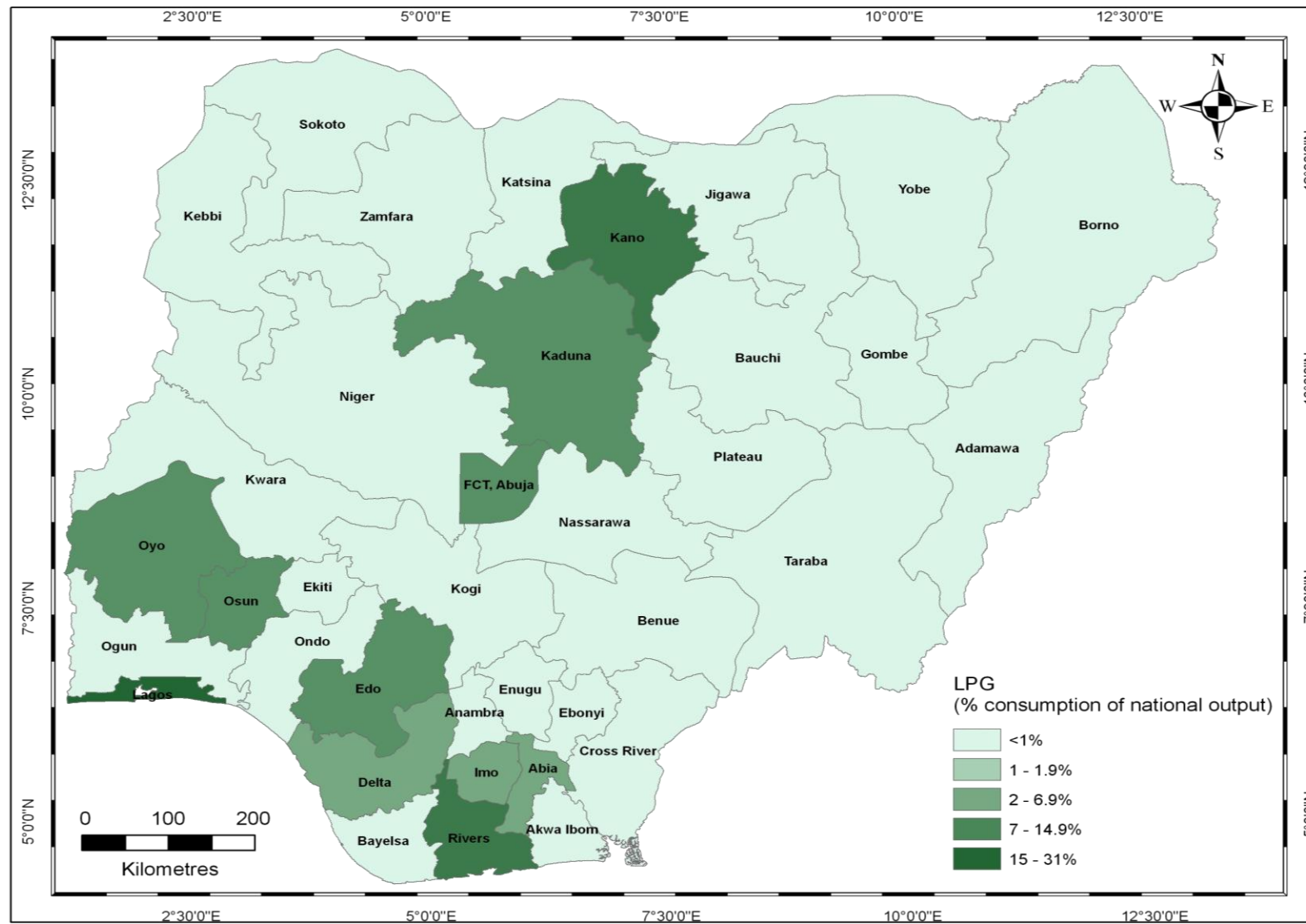


Figure 6.6: LPG Distribution by States in 2010

country depends on road transport¹³.

As outlined in figure 6.7, only Lagos state and the FCT receive a substantial supply of PMS. A few states (North-Central and South-West) receive a moderate supply, while the majority receive a limited supply of the commodity. A comparison of PMS supply (figure 6.7), with the household fuelwood usage (figure 6.2) reveals that while Lagos state and FCT receive a large supply of PMS and use less fuelwood, the consumption pattern of the latter in other states does not consistently follow the supply pattern of PMS.

On a broader scale (figures 6.2 and 6.4), the supply of modern cooking fuel in Nigeria is precarious, since the south receives more than the north. While this partially explains why the majority of the northern states predominantly depend on fuelwood for their cooking, a comparison of figure 6.2 with figures 6.5- 6.7 shows that some states (both in the south and the north) that receive a substantial supply of certain modern fuels, also use a large amount of fuelwood for their cooking. Several questions arise from this, such as; why are there such differences in the fossil fuel supply among the various states? Or what factors are responsible for the differences in the use of fuelwood among the various states in Nigeria? The answers to these questions remain unclear and are rarely discussed in the literature. They will therefore now be examined by means of Geographically Weighted Regression (GWR) analysis.

6.4. Spatial heterogeneity in the consumption pattern of fuelwood in Nigeria

The possible factors that may contribute to the disparity in the use of fuelwood among Nigerian states have been explored using GWR in ESRI's ArcMap 10 Software. The details of the method were presented in chapter 5, while this section examines the results. Although a number of original variables were considered in the analysis (see table 6.2 below & table 5.1 in chapter 5:5.4.2 for more detail), they were subsequently grouped into three broad classes using Principal Component Analysis (PCA) and Ordinary Least Square (OLS) regression in order to reduce the effect of multicollinearity in the model (refer back to chapter 5: 5.4.3-5.4.3.1 for detail).

¹³ Despite the long existence of the railway system in Nigeria (more than ten decades), the lack of effective management of the Nigerian Railway Corporation's (NRC) infrastructural development by the government over the years has led to the dilapidated state of the railway system in the country (Odeleye, 2000). It was observed that the last rail track was laid from 1958 – 1968, which bring the total length of the current track routes (old narrow-gauge single track) in the country to 3,505km (Odeleye, 2000, p. 43 & NRC, 2010). After more than two decades of stagnation (Akiyoye, 2013 & Echenim, 2013), the NRC has commenced operation in 2012 as well as infrastructural maintenance of some of their old tracks and the renewal of others. They have also initiated the supply of 25 new locomotive engines to boost the existing ones in the corporation (NRC, 2010). However, all these initiatives are yet to manifest themselves effectively in the country's transportation system (Echenim, 2013 & Nmodu, 2013).

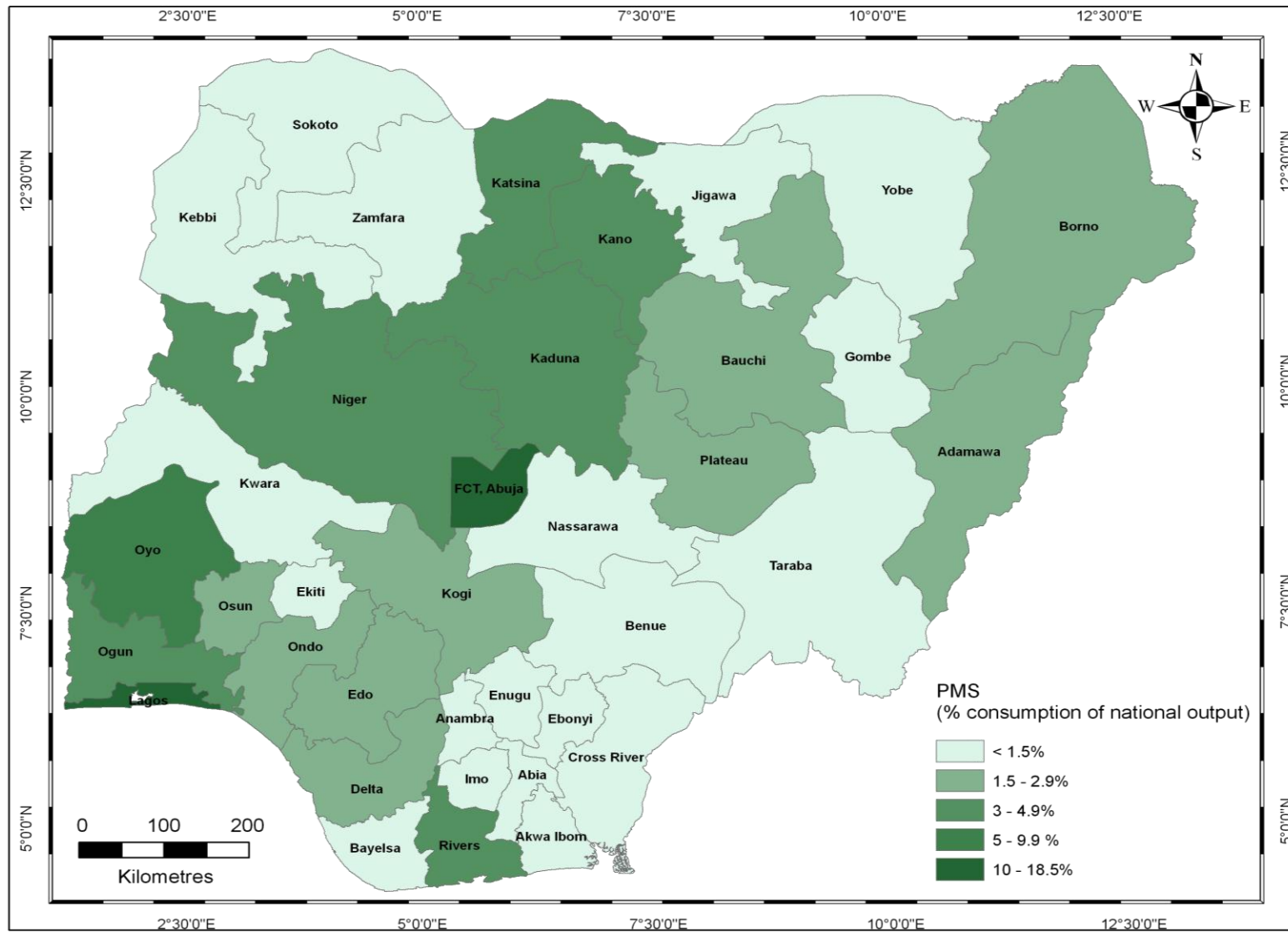


Figure 6.7: PMS Distribution by States in 2010

6.4.1. The Results of the PCA and OLS Regression Diagnostic Model

Three orthogonal components were identified from the PCA results accounting for a cumulative variance of 86% in original variables using a cut-off point value (Eigenvalues) of 1 (table 6.1 and 6.2). The first PCA contributed 50.9% of the total variance while the second and third contributed 23.6% and 11.6% respectively (table 6.1). The three PCA components are named based on their loadings in relation to the original variables. From table 6.2, the first component had positive loadings on flats in block of flats, rented houses, educated adults, and the supply of fossil fuel, while the rest of the variables had loadings that were either negative or close to zero. This mixture of characteristics describes those states that are actively engaged in industrial activities (concentration of industries or commercial activities), so these are therefore referred to here as “INDUSTRIAL STATES”.

Table. 6.1: Total Variance Explained by the PCA Method

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.586	50.955	50.955	4.586	50.955	50.955
2	2.132	23.691	74.645	2.132	23.691	74.645
3	1.047	11.628	86.274	1.047	11.628	86.274
4	.744	8.261	94.535			
5	.246	2.733	97.268			
6	.095	1.051	98.319			
7	.079	.877	99.196			
8	.052	.583	99.779			
9	.020	.221	100.000			

Table 6.2: Principal Component Matrix Extraction (3 Components Extracted)

	Component		
	1	2	3
% >Three Rooms	-.307	.847	.233
% Unemployed	-.299	-.232	.912
% Detached House	.037	.911	-.113
% Huts	-.913	-.336	.099
% Flats in block of flats	.940	.011	.204
% Rented	.902	-.308	-.086
% Educated >15yrs	.893	.251	.230
% Children <15yrs	-.914	-.145	-.173
% FFuel (00 Litres) Per Pop	.489	-.488	-.080

The second component had positive loadings on households with more than three rooms, detached houses and educated adults, while the remaining variables had loadings that

were either negative or zero. This component describes states where the main activities are either agriculture for subsistence or commercial activities. So these states are categorised as “LESS INDUSTRIAL STATES”. The third component had positive loadings on unemployment, households with more than three rooms, and educated adults. The last of these is perhaps strange, given that all the other variables positively associated with the third component are indicating some level of deprivation. However, the component is retained at this stage and describes “DEPRIVED STATES”. The third component was retained because all the three components were subsequently examined using OLS for purposes of statistical validation before using them in further analysis (see section 6.4.1.2.). Therefore the new model variables to explain the situation of fuelwood use in Nigeria are the three resulting components of the PCA, named to identify the groups of states with which they are most closely associated (industrial states, less industrial states and deprived states)¹⁴.

6.4.1.2. Testing the Model Variables Using OLS Regression

OLS is a global linear modelling technique used to predict values using one or more explanatory variables and it can also show the strength and weakness of the relationships between these variables (Hutcheson & Sofroniou, 1999, p. 55). The use of an OLS regression model is regarded as good practice for model fitting (Fotheringham et al., 2002 & Charlton & Fotheringham, n.d). So this approach was used to examine the relationships between the dependent variable (fuelwood use among households in Nigeria) and the independent principal components (industrial states, less industrial states and deprived states). The spatial statistics tools of the Arc Toolbox in ArcGIS Software package was used in running the OLS model (ESRI, 2010).

Finding a properly specified OLS model is often an iterative process. Therefore the first step in the procedure was to include all three components as explanatory variables. From the results of this first OLS regression (OLS_All) presented in table 6.3 below, the coefficients of the industrial states (negative) and less industrial states (positive) are in the expected direction with fuelwood use.

¹⁴ Note that the names (industrial, less industrial and deprived states) are somewhat arbitrary and given for the convenience of relating the effects of the variables on fuelwood use, because there are no supporting arguments from the literature that specifically justified the choice of these names.

Table 6.3: Summary of OLS_All Results

Variable	Coefficient	StdError	t-Statistic	Probability	Robust_Pr	VIF [1]
Intercept	59.733050	1.385419	43.115511	0.000000*	0.000000*	-----
INDUST_S_1	-14.004008	1.461785	-9.580073	0.000000*	0.000000*	1.057598
LESS_IND_1	10.054367	1.898750	5.295256	0.000007*	0.000294*	1.057219
DEPRIVED_1	-0.581525	1.375677	-0.422719	0.675241	0.513758	1.000371

*Significant= P<0.05

However, the deprived states component is negatively correlated with fuelwood use. This is unanticipated because the use of fuelwood would be expected to increase as the level of deprivation increases. One possibility is that the model might be lacking some key explanatory variable elements, but no guidance is available from the literature. Another issue is the significance of the probability tests. The probability and robust probability columns from table 6.3 above, measure the statistical significance of a coefficient. Given that the deprived states coefficient is reported as being insignificant, this indicates there is no justification for including the deprived states component in the overall model. For that reason, the OLS model was re-run with only industrial states and less industrial states components (OLS_ND). The results are presented in table 6.4.

Table 6.4: Summary of OLS_ND Results

Variable	Coefficient	StdError	t-Statistic	Probability	Robust_Pr	VIF [1]
Intercept	59.741034	1.368456	43.655782	0.000000*	0.000000*	-----
INDUST_S_1	-13.992133	1.443755	-9.691488	0.000000*	0.000000*	1.057208
LESS_IND_1	10.051729	1.875666	5.359017	0.000006*	0.000284*	1.057208

*Significant= P<. 05

From table 6.4, both industrial and less industrial states retained their coefficients in the expected direction with fuelwood use, and were all statistically significant (robust probability; 0.0000 & 0.0003 respectively). Also, given that the variance inflation factor values (VIF) for the industrial states and less industrial states components are only just above one, there is no redundancy among the two explanatory variables (i.e. the two variables are capturing dimensions of variation). This suggests that the choice of the explanatory variables in the model is justified. Further checks on the choice of the two variables were conducted and are presented as the OLS Diagnostics test results in table 6.5.

Table 6.5: OLS Diagnostics Test Results

OLS Diagnostics			
Number of Observations:	37	Akaike's Information Criterion (AICc) [2]:	267.227431
Multiple R-Squared [2]:	0.753828	Adjusted R-Squared [2]:	0.739347
Joint F-Statistic [3]:	52.057385	Prob(>F), (2,34) degrees of freedom:	0.000000*
Joint Wald Statistic [4]:	73.671409	Prob(>chi-squared), (2) degrees of freedom:	0.000000*
Koenker (BP)Statistic [5]:	11.078385	Prob(>chi-squared), (2) degrees of freedom:	0.003930*
Jarque-Bera Statistic [6]:	3.048885	Prob(>chi-squared), (2) degrees of freedom:	0.217742

*Significant= P<.05

Several test results from this table can be highlighted. Firstly, the significance of the model coefficients is confirmed by the Koenker (BP) statistic¹⁵. However, this statistic indicates that the relationships between the explanatory variables and the dependent variable are non-stationary. This means, for example, that the industrial and less industrial states components are important predictors of fuelwood usage in some states of Nigeria, but perhaps weak predictors in other states. Looking at the performance of the model (Adjusted R-Squared from table 6.5), the model explains about 73.9 % of the total variation in the use of fuelwood in Nigeria. The Jarque-Bera test is not statistically significant and therefore the model is said to be unbiased, which means that the model is not missing key explanatory variables¹⁶. This is helpful in addressing concerns raised in relation to the eliminated third component.

Finally, the significance of the model residuals are tested to make sure that they are free from spatial autocorrelation (spatial clustering of over and under predictions). This was achieved using ArcMap's spatial statistics tool (analysing pattern- Spatial Autocorrelation (Moran's I))¹⁷. The result of the Morans I test is presented in table 6.6 and figure 6.8.

Table 6.6: OLS Global Moran's I Summary

Summary	
Moran's Index:	0.168699
Expected Index:	-0.027778
Variance:	0.016712
z-score:	1.519832
p-value:	0.128553

The results of the Spatial Autocorrelation test (table 6.6 and figure 6.8) on the model's regression standardised residuals, indicates a random distribution. The z-score is not statistically significant (1.52), so the null hypothesis of complete spatial randomness of the residuals is accepted.

¹⁵ When the Koenker (BP) statistic is statistically significant, the significance of the Robust Probability column has to be considered. This has been reported earlier and the values are significant for both of the two model coefficients (refer to table 6.5) (Charlton & Fotheringham, n.d).

¹⁶ The Jarque-Bera test measures whether or not the residuals from the regression model are normally distributed. The residuals (over/under predictions) from a properly specified model will reflect random noise (Charlton & Fotheringham, n.d). Random noise has a random spatial pattern (no clustering of the residuals) (see the model output examples in figures 6.8 & 6.9).

¹⁷ The Global Moran's I statistic test measures the spatial autocorrelation of the model residuals based on their areal locations and their attribute values (Charlton & Fotheringham, n.d).

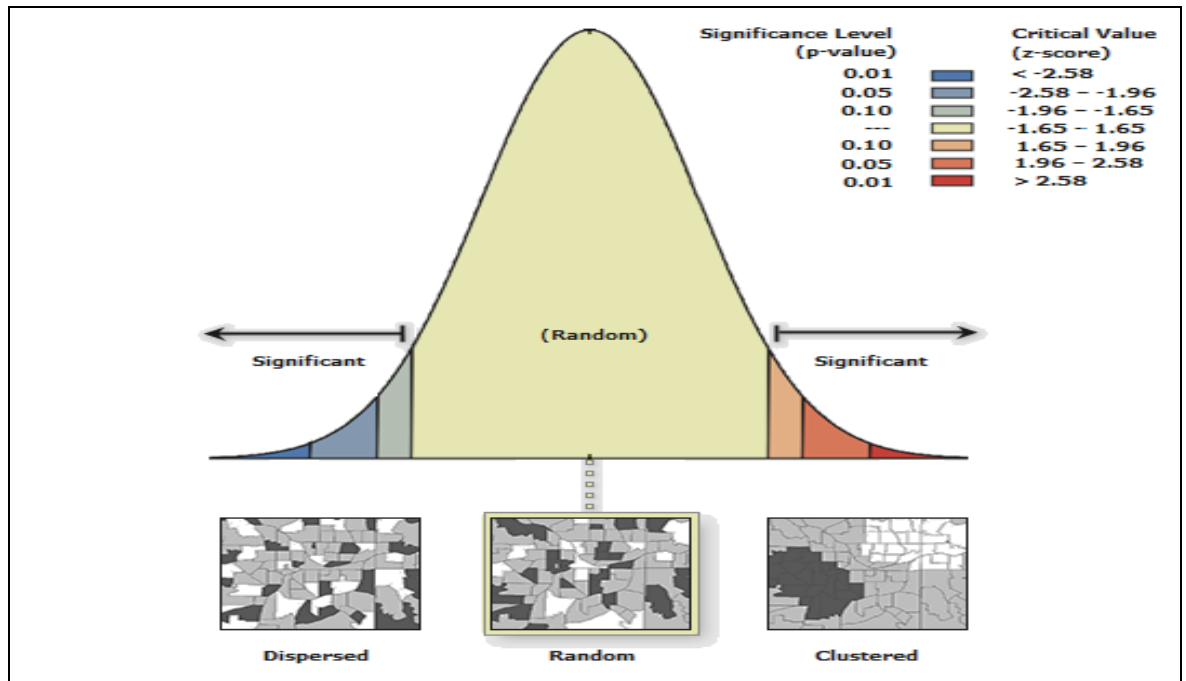


Figure 6.8: OLS Model Spatial Autocorrelation Report Output

(N.B: Given the z-score of 1.52, the pattern does not appear to be significantly different from random)

Since the test results (OLS and Moran's I) have all confirmed the significance of the model choice in explaining the variation in the use of fuelwood in Nigeria, but the Koenker (BP) statistic (table 6.5) is also statistically significant, the model results are likely to be improved by using GWR.

The GWR model was run using ArcMap's spatial statistics tool (modelling spatial relationships- Geographically Weighted Regression). The result of the GWR model is presented below (table 6.7).

Table 6.7: GWR Model Results

Neighbors	: 37
AICc	: 265.58409235247643
R ²	: 0.79279987210570135
Adjusted R ²	: 0.76088161343860738

From table 6.7, there is some improvement in the model compared to the OLS model discussed above. Using 37 neighbours to calibrate the local regression equation, the GWR yields more optimal results than the OLS (minimising bias and maximising model) based on Akaike's Information Criterion (AICc) method. For example, the Adjusted R² value is higher for GWR than it was in the OLS model (OLS was 73.9%; GWR is 76.1%). The AICc value is also lower for the GWR model (265.6) compared with the OLS (267.2). This minor decrease indicates a small improvement in the model performance when GWR is used.

The standard residuals of the GWR model were also tested using the Spatial Autocorrelation tool in ArcMap described earlier. The Spatial Autocorrelation result presented in table 6.8 and figure 6.9 below, also confirmed that the z-score is statistically insignificant, therefore the null hypothesis of complete spatial randomness in model residuals is accepted and the results of the coefficients were accepted as significantly describing the spatial variation of fuelwood use between the 36 states in Nigeria (and FCT).

Table 6.8: GWR OLS Global Moran's I Summary

Moran's Index:	0.102292
Expected Index:	-0.027778
Variance:	0.016027
z-score:	1.027423
p-value:	0.304222

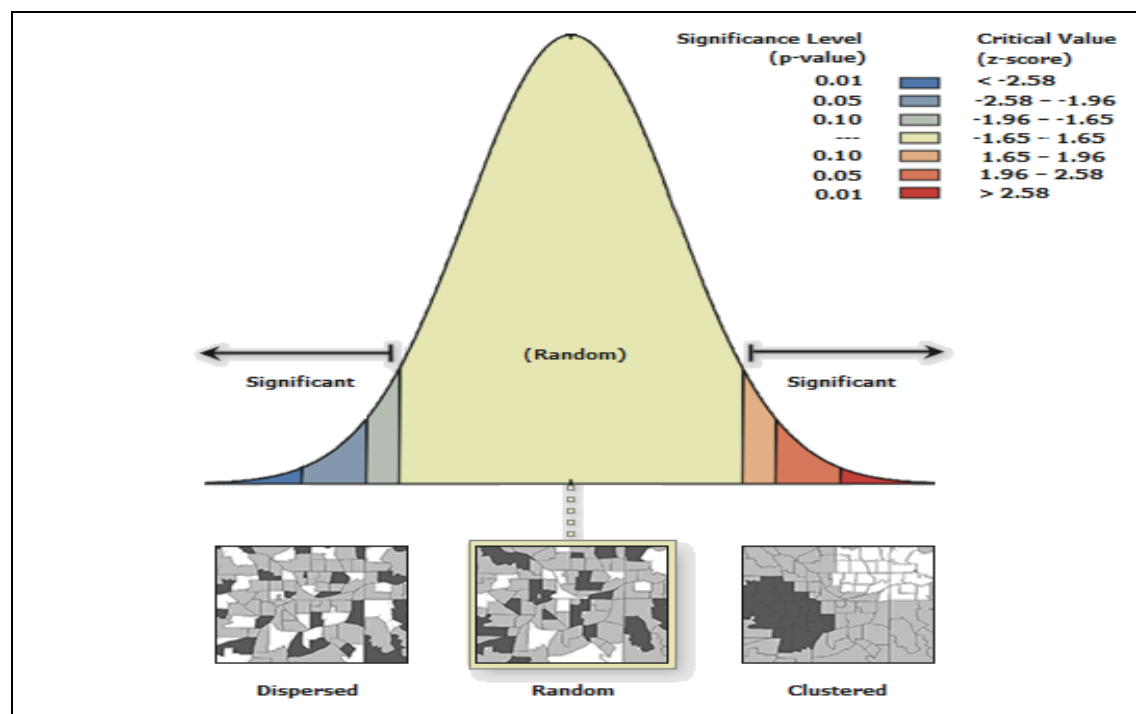


Figure 6.9: GWR Model Spatial Autocorrelation Report Output

(N.B: Given the z-score of 1.03, the pattern does not appear to be significantly different from random).

6.4.2. Local Regression Parameter Estimates from the GWR

One of the primary advantages of GWR is the ability to visualize the local regression coefficient estimates in order to identify local model heterogeneities (Wheeler & Tiefelsdorf, 2005). However, visualization of GWR results has remained a focus of debate according to Charlton and Fotheringham, (n.d, p. 7). While these authors noted that presenting local test results from a GWR raises the problem of running multiple

significance tests, Mennis (2006) and Tsai (2011) recommend that mapping of local parameters should include both the coefficient and the t-value side by side on the same map. When this is done, the reader can effectively visualize where the coefficient results are significant or not. The maps in figure 6.10 are therefore provided in accordance with the recommendations of Mennis' (2006) and Tsai's (2011).

Figure 6.10a, classifies individual states based on their component scores (PCA loadings). Only the North-East states of Nigeria (NEN) are fully in the less industrial category, while Lagos and Delta states in the south and the FCT tend towards the industrial category. The remainder of the states load equally on both PCA components- either belong to the less industrial- all from the northern part, or have the attributes of both industrial and less industrial states- Kano, Kaduna, Nasarawa, Kogi and Kwara in the north and all the southern states (with exception of Lagos and Delta states).

Reporting the standardised residuals is good practice (Charlton & Fotheringham, n.d, p. 6) as they indicate where the unusually high and low residuals are located. Surprisingly, the majority of the states that consume a high percentage of fuelwood (see figure 6.2 above) have positive residuals (Std Res >0.5 - see section 6.4.1.2). However, a few states in the south that use less fuelwood have positive residuals, while a few from the north that use large amounts of fuelwood have negative residuals. The model, therefore, highlights possibilities of over or under-prediction of the fuelwood use in those states. Evidence from the spatial autocorrelation tests on the GWR residuals (see section 6.4.1.2 - table 6.8 and figure 6.9), shows that $p= 0.30$, which indicates minimal autocorrelation in the results. This implies the observed residual values do not indicate statistical problem with the model. So it is appropriate to report the final coefficients from the model as they stand, taking aboard the likelihood of over or under estimation of parameters in some states.

The sign of the coefficients for the industrial states component with fuelwood use (figure 6.10 b) indicate a negative relationship. This is in the expected direction, because, where there are a large number of flats in a block of flats, rented accommodation, educated adults, and an ample supply of fossil fuel, fuelwood use will tend to decrease. However, the range of coefficient values is only between -11.34 in the north and -15.14 in the southern states. These small variations in the negative coefficients indicate that there is a little variation in the nature of fuelwood use among the industrial states. The t-test values

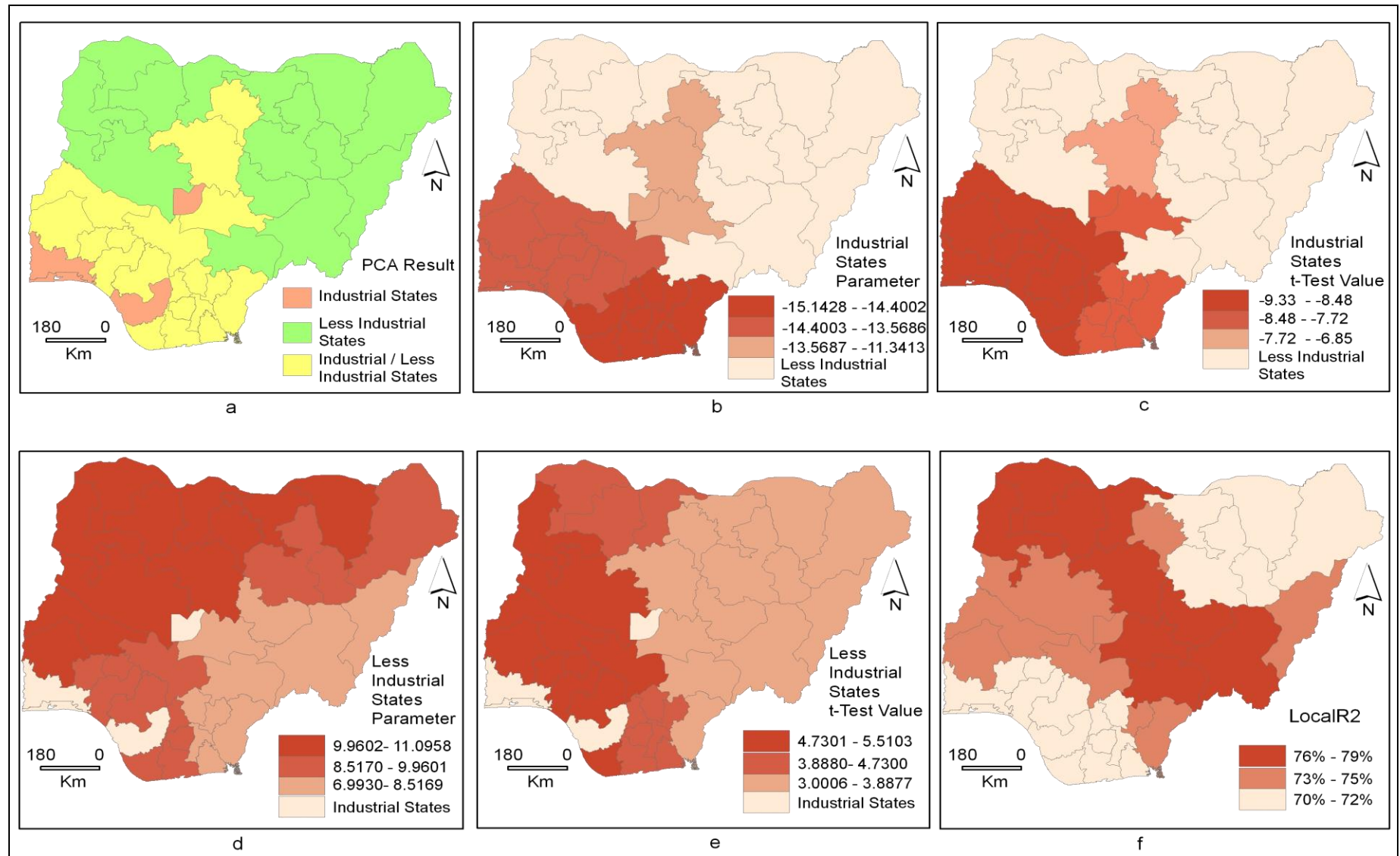


Figure 6.10: Spatial Distribution of the Parameter Estimates of Fuelwood Consumption in Nigeria

a) Result of PCA (the mapping was based on the two principal component Analysis loadings); b) and c) are the GWR parameter estimates and t-values for Industrial states; d) and e) are the GWR parameter estimates and t-values for Less Industrial states; f) spatial distribution of local R^2 values.

(figure 6.10 c) confirm the significance of these coefficients. This may be because the lifestyles of the people in the industrial states are more homogeneous, in terms of competitive urban/ industrial employment, than in the less industrial states. Also, family settings are more of a nuclear type, which will increase the chance of using fossil fuels rather than fuelwood, due to space restrictions. Another factor that may affect the use of fuelwood in the industrial states is the long hours most people spent away from home in the office or workplace. This contrast with the lifestyle of traditional agricultural families in the less industrial states whose work commitments vary with the passage of the seasons (see further discussion in chapter 10: 10.4.1.4).

On the other hand, the strong positive relationship shown by the coefficients for less industrial states (7 to 11.09) (figure 6.10 d), is also in the expected direction. This is because, when there are numerous households with extended family systems, rural detached houses and compounds, it is likely that in these rural settings, the vast majority of the population will practice subsistence farming (rain fed agriculture), and rely on locally available resources, especially from their farms. This situation reflects the nature of Nigerian society, where the majority of the population still depend on subsistence agriculture (NPC & ICF Macro, 2009). The t-test value of the coefficients (figure 6.10 e) confirmed the significance of the direction of association between the less industrial components and fuelwood use.

This quantitative analysis using component scores and GWR therefore serves to underline the key importance of wood as a cooking fuel for the majority of households in Nigeria. While the degree of urban/industrial development and availability of alternative fuel supplies have important effects to date, these have not been sufficient to cause major shifts away from traditional fuel requirements in the country as a whole.

6.5. Discussion of cartographic and statistical findings

6.5.1. Fuelwood Versus Other Cooking Fuel Types in Nigeria

The summary of the cooking fuels used by households in Nigeria (figure 6.1), revealed that the southern part of the country use more fossil fuels (kerosene and gas) for their cooking than their northern counterparts, whose cooking fuel choice is related to the erratic supply of fossil fuel in the region.

Despite this variation in the most usable form of energy in the country, the use of fuelwood among households has become the accepted norm in most locations. While this situation is the same as observed in other DC (Kebede et al., 2010), the case of Nigeria requires close attention, because the size of its forest reserves has drastically reduced in recent times (refer to chapter 2: 2.2.2 - 2.2.2.1; FAO, 2010a, p. 21 & FAO, 2011b, p. 3 for detail). The high levels of fuelwood consumption among households in the country reported here agree with the findings of Adelekan and Jerome (2006) and Maconachie et al. (2009) in both the southern and northern part of Nigeria respectively.

Even though the total amount of fuelwood use in Kano and Kaduna states in the north far exceeds any other state in the country (refer to figure 6. 1), because of their population (first and third respectively in the country, with a combined total population exceeding sixteen million people- NPC, 2009a), they have a similar proportion of fuelwood use as the rest of the northern states (over 65% of their households solely depend on this fuel- see figure 6.2).

Similarly, the country's regions do not show any substantial variation in terms of the transition from the use of fuelwood to the use of modern cooking fuel. The explanation for this limited variation in the use of cooking fuel lies with the high price and unreliability in the supply of modern cooking fuel (Adelekan & Jerome, 2006 & Maconachie et al., 2009; see also the findings of chapters 8 & 10)¹⁸. These factors have favoured the reversion of the majority of the households from the use of modern cooking fuels back to traditional fuelwood in recent times (Adelekan & Jerome, 2006).

Some authorities have argued that the use of fuelwood is largely found in lower income families in the DC (Adelekan & Jerome, 2006; Kowsari & Zerriffi, 2011 & Sovacool, 2011), which contrasts with the ways fuelwood is being used in the developed countries. Couture et al.'s (2012) study of the use of fuelwood for heating among families in France shows a reverse relationship between fuelwood use and income, because affluent families use fuelwood for pleasure rather than from necessity. The present findings (see further discussion in chapter 8) contrast with both these studies, because the difference between the rich and the poor in terms of fuelwood use is negligible, especially in the northern states of Nigeria, where even the affluent families, have to rely on fuelwood for their cooking, due to the shortage of modern fuel supply (Maconachie et al., 2009).

¹⁸ Refer to chapter 2: 2.5.1.3 for the history of fossil fuel price increases in Nigeria.

6.5.2. The Strategy of Fossil Fuel Distribution in Nigeria

Contrary to the energy ladder concept (figure 6.11 below) that assumes ready availability and uniform supply of all fuel types, so households can choose their cooking fuel based on their income level¹⁹, the case of Northern Nigerian fossil fuel supply is different, because it is erratic and in some cases insufficient (Maconachie et al., 2009). This makes the 'choice' of cooking fuel by households a matter of availability, rather than the genuine selection between alternatives emphasised in the energy ladder (see chapters 8 & 10 for more detail).

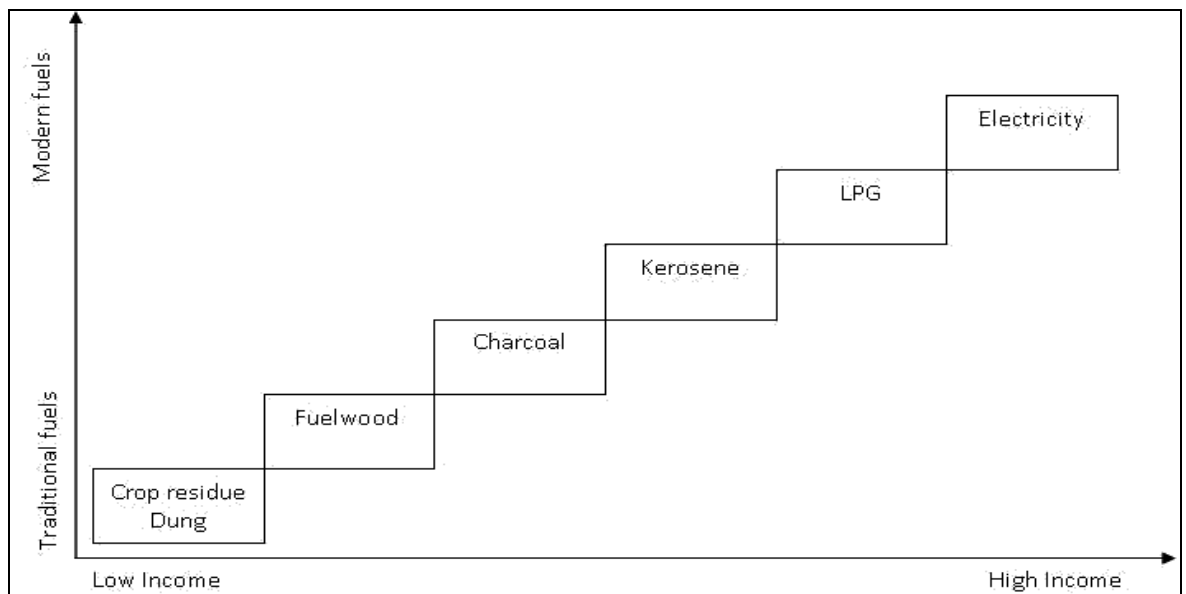


Figure 6.11: The Classic Energy Ladder

Source: Kowsari and Zeriffi (2011, p. 7508).

For example, analysis of the zonal distribution of fossil fuels in Nigeria (figure 6.4 above) shows an inconsistency in their distribution. Lagos, Ogun and Oyo states in the South-West and Rivers and Delta states in the South-South have large concentrations of industries that can justify these two regions' having the largest shares of overall fossil fuel distribution in the south. However, in the north, although the North-Western states of Kano and Kaduna have the highest concentration of industries they only receive 5.92% of the total supply of fossil fuels in the country.

Again, looking at the regional population distribution (figure 6.4 above), it is clear that the distribution strategy for fossil fuels among the various states is not population dependent. For example, while the combined population of the southern part of the

¹⁹ "The energy ladder emphasised that households choose to move up the ladder as soon as they can afford to do so" (Kowsari & Zeriffi, 2011, p. 7508).

country is 46.4%, it receives about 68.18% of the total fossil fuel. In contrast, the north with a population of more than 52.6% (excluding Abuja) only receives 26.91%, while Abuja, with a 1% of the population receives 4.91% of all fossil fuel.

Another factor that may affect the supply pattern of modern fuel is the concentration of oil related activity in the south. While this is true, the refineries in this region are not fully functional (PPMC, 2010), which is why Nigeria has to rely on the importation of refined fossil fuel, while its crude is being exported (see chapter 2: 2.5.1 for more detail). Also, there is a pump price regulatory body in the country, under the Petroleum Equalisation fund Management Board (PEF (M) B)²⁰ *“to deal with the problem of cost differentials arising from the transportation of petroleum products to various parts of the country, based on a uniform pricing policy”* (Ehinomen & Adeleke, 2012, p. 236).

There are allegations of sabotage among the petroleum product supplying regulators that hampers the steady supply of fuel to the north. An example was a report in the cover story of Leadership Newspaper edition of 02/08/2011 entitled *“NUPENG uncovers fuel supply sabotage plot in North”* (Alohan, 2011a). This report quoted the Kaduna Zonal executive of National Union of Petroleum and Natural Gas Workers (NUPENG) saying that; *“we have painfully uncovered a grand design by a group of disgruntled elements who are not happy with the free flow of petroleum products in the entire northern states....., who have started making efforts to disrupt it by circulating false information around..., which we believed is a hidden plot to destabilise the free flow of petroleum products to the north”*.

A second report in the same newspaper’s edition of 24/06/2011 (Alohan, 2011b) entitled; *“Kerosene scarcity: NNPC punctures IPMAN’s lopsided allocation claim”*, addressed similar issues. In the report, the NNPC’s General Manager of Public Affairs Division, Dr. Levi Ajuopnuma, faulted the claim made earlier by Alhaji Aminu (president of a factional group of Independent Petroleum Marketers Association of Nigeria (IPMAN)), that accused NNPC of disproportionate allocation of kerosene in favour of the major marketers (refer to chapter 2: 2.5.1.3 for more detail on marketers; and see table 6.9 below for a summary of the petroleum retailers in the country).

²⁰ It is a parastatal (organisation) in the Federal Ministry of Petroleum Resources established by Decree No.9 of 1975 (as amended by Decree No. 32 of 1989) to create a uniform petroleum products pump price policy in Nigeria.

Table 6.9: A Summary of the Nigerian Petroleum Retailers

Geo - Political Zone	Marketer type		Total No of Outlets
	Major	Independent	
North Central	355	1318	1673
North East	163	726	889
North West	265	1023	1288
South East	194	1227	1421
South South	224	1519	1743
South West	1017	2135	3152
TOTAL	2218	7948	10166

Source: Petroleum Products Pricing Regulatory Authority (PPPRA, 2004).

(<http://www.pppra-nigeria.org/distributionsummary.pdf>)

(N.B. This information is based on the PPPRA's 2006 census. There are six major oil marketers in Nigeria- Oando Nig. Plc; Mobil oil Nig. Plc; Total Nig. Plc; African Petroleum Nig. Plc; Texaco Nig. Plc & Conoil Nig. Plc).

Although the claim was countered by the accused, the matter should have been investigated further, because it could be a possible reason for the uneven distribution of petroleum products between the south and the north (as shown in this study), since the total number of the marketers is much higher in the south than the north (1,435 to 783 major marketers; and 4,881 to 3,063 independent marketers- see table 6.9). In addition, Ehinomen and Adeleke (2012, p. 241) faulted the distribution system of petroleum products in Nigeria as being ineffective due the full control of the sector by the government. They therefore recommended the deregulation of the downstream sector of the petroleum industry in order to allow private investors and entrepreneurs to fully participate in the sector, a situation that should lead to improved effectiveness in the distribution of the product.

It should be remembered that even the figures of the fossil fuel distributions provided by the NNPC (used in this study), may not reflect the true amount of the final products reaching the majority of the northern states. Again, this can be attributed to various allegations of misconduct and sabotage in the country's petroleum regulation sector (refer to chapter 2: 2.5.1 - 2.5.3 for more details). For example, earlier researchers have reported smuggling as the key factor responsible for the product shortage in the country (particularly the northern part- Odihi, 2003; Maconachie et al., 2009 & Garuba, 2010). However, in January, 2012, the Nigerian Government withdrew part of the fossil fuel subsidy (see chapter 2: 2.5.3), in an attempt to eradicate the misconduct of the petroleum marketers, by applying a fair price policy. The government believed this would remove the financial incentives for smuggling and increase supplies. Unfortunately, this has not proved to be the case because the northern states continue to witness shortage

in the fossil fuel supply, while the prices of all other household commodities have increased by about 65 percent compared to their original price prior to the subsidy withdrawal (This Day Newspaper, 2012). These sharp price increases are attributed to the increase in the cost of transportation, which has risen by 100 percent or more. Another new factor is that both Niger and Chad Republic, once considered the best places to sell Nigerian smuggled products (Garuba, 2010), have recently started refining their petroleum products, while the Cameroun Republic (another smugglers' destination, particularly in the north), will shortly follow suit (BBC Hausa, 2012b).

These recent positive developments in neighbouring countries do not seem to have produced any major change in the fossil fuel shortages in Northern Nigeria (BBC Hausa, 2012a) to date. It is therefore, unclear at this stage; whether this situation will start to change in future. At this stage, it is difficult to completely discard the claims of earlier researchers that smuggling was key factor in supply shortages in favour of the findings of this study, that there is a precarious distribution strategy, which favours some regions. However, only time can substantiate either or both of the two claims, and the rider reported by Odihi (2003), that the northern Borno state's share of the modern fuel supply is sufficient for its requirements, particularly if the product is utilised properly in the state, rather than smuggled out. Such claims can only be objectively tested in the future, given that the circumstances in the neighbouring countries he claimed the products were smuggled to, have only changed recently.

6.5.3. The Driving Forces of Fuelwood Consumption in Nigeria

6.5.3.1. Current Trends in Unemployment Related Issues

The high rate of unemployment in Nigeria (23.9% percent of Nigeria's population are unemployed- Eroke, 2012), is also relevant to the affordability of fossil fuel and the extensive use of fuelwood. A more recent development relating to poverty and social injustice in Nigeria is the emergence of "*Boko Haram*" in the north (for a comprehensive discussion, refer to Amnesty International Report, 2012 & Box 6.1 below for a summary of the group's activities).

The *Boko Haram* crisis has generated a huge debate in the country, about the cause of the conflict and ways of resolving it. From the statements of leading stakeholders engaged in the debate, it is obvious that the majority of the arguments lean towards

poverty and unemployment among youths in the region. These arguments are now widely circulated by the media. Attention has also centred on the subsistence agriculture, on which the region formally depended, because this is no longer viable, especially with the increasingly high cost of fertilisers (Porter et al., 2003) and other farming activities in the country (BBC Hausa, 2013). The neglect of the agricultural sector in the region is attributed to a lack of commitment by the government in assisting farmers, by regulating the price of their crop outputs and the supply of fertilisers.

Box 6.1: Who Are Nigeria's Boko Haram?

"Boko Haram in the Hausa language means 'Western education is forbidden'. The group's official name is Jama'atu Ahlis Sunna Lidda'awati wal-Jihad, which in Arabic means 'People Committed to the Propagation of the Prophet's Teachings and Jihad'. A charismatic Muslim cleric, Mohammed Yusuf (now deceased), formed the group in the north east of Nigeria (Maiduguri) in 2002. He set up a religious complex, which included a mosque and an Islamic school. Many poor Muslim families from across Nigeria, as well as neighbouring countries, enrolled their children at the school. In 2009, Boko Haram carried out a spate of attacks on police stations and other government buildings in Maiduguri. This led to shoot-outs on Maiduguri's streets. Hundreds of Boko Haram supporters were killed and thousands of residents fled the city. Nigeria's security forces eventually seized the group's headquarters, capturing its fighters and killing Mohammed Yusuf in a controversial way. His body was shown on state television and the security forces declared Boko Haram finished. But its fighters have regrouped under a new leader and in 2010; they attacked a prison in Bauchi state, freeing hundreds of the group's supporters.

Boko Haram's trademark has been the use of gunmen on motorbikes, killing police, politicians and anyone who criticises it, including Muslim clerics and Christian preachers. The group has also staged several more audacious attacks in different parts of northern Nigeria, showing that it is establishing a presence across the region and fuelling tension between Muslims and Christians. These include the bombing of the police headquarters and the UN headquarters in Abuja".

Source: BBC African Service- Chothia (2012).

However, in October 2012 the Minister of Agriculture and Rural Development, Dr Akinwumi Adesina, made a statement refuting all the allegations of being unsupportive of the farmers. The newspaper report of this stated that; *"the FG, through its Agricultural Transformation Agenda (ATA) has increased domestic food supply by 8.1 million tonnes in 120 days (from May, 2012 to September, 2012) ..., which was achieved as a result of government withdrawal from the distribution of fertiliser. He alleged that the problem in the past was that for more than four decades, the government had always bought fertiliser and distributed it which ended up in the hands of the rich farmers and the political farmers, who export it out of the country. According to him one can hardly find it in the hands of the poor farmers",* NAN (2012b). This lack of support by the government in the past has pushed away many poor families from practicing full time agriculture into other "unrealistic" sectors such as being political touts (BBC Hausa, 2013). These reasons and of course, other "obvious" and "hidden" reasons (some of which have been discussed

in previous chapters) must have reduced the purchasing capabilities (of fossil fuels, even if they were made available) of most families in the region.

6.5.3.2. Corruption and Revenue Allocation in Nigeria

Corruption is another issue that has hampered the establishment of social services that can discourage people from relying on traditional fuelwood. For example, there have been various attempts by the government since 1960 to design an efficient and equitable revenue distribution formula in the country with little success, largely because there have been no *“reliable or acceptable socio-economic data on which a technical impartial allocation can be based”* (Omotoso, 2010, p. 250). The Revenue Mobilization Allocation and Fiscal Commission (RMAFC), which is a commission under the presidency, have the mandate to determine the country’s revenue allocation formula. The commission’s roles were specified in the 1999 Nigerian constitution under section 162(2) (RMAFC, 2012). The commission’s existing revenue formula allocates 52.68% of the total revenue to the Federal Government (FG); 26.72% to the 36 State Governments (SG); while 20.60% goes to the over seven hundred Local Governments Areas (LGA) in the country (Alli, 2012). It should be noted that because over 90% of national revenue is generated from the export of crude oil, a special top-sliced allocation of 13% of all the crude oil export revenue is allocated to the oil producing states of the southern part of the country.

Although, the FG receives the largest share of the allocation, it also allocates 6.5% of its total share as a reserve for Special Funds. The 6.5% reserved for the Special Funds is disbursed in the following order; Ecological Fund (1.50%); Solid Mineral Fund (1.75%), National Reserve Fund (1.50%) and Agricultural Development Fund (1.75%) (Alli, 2012). This is the allocation formula in theory, but in reality, it is not practiced. For example, the allocation of the LGA directly goes to the SG in the name of a “Joint Account”. This situation places the LGA at the mercy of the SG, which disburses (to the LGA) part of the LGA allocation at their will. Similarly, as argued by Omotoso (2010), the SG is also at the mercy of the FG, because they constantly pressurised the FG for more funding from the FG’s share. This is an indication of under-funding of the SG given that some of them cannot even pay the basic monthly salary of 18,000 Naira (about £72) to their workers, especially the northern states, despite holding the LGA’s allocation as well. Also, the Ecological Fund, under the Special Funds of the FG’s share, is being distributed to the various SG to tackle environmental issues. Again, the fund is being abused by the SG,

because the majority of them use the money on other projects to the detriment of the intended environmental projects. This latter situation directly compounds the environmental problems in the country, especially the issue of desertification control in the north and erosion control in the south.

On the other hand, the special 13% allocated to the oil producing states does not seem to have a beneficial impact on the social well fare of the respective states²¹. It is therefore, obvious that the revenue allocation in Nigeria, like its industrial distribution and population distribution, is uneven. But apart from the general lack of local level funds, the revenue distribution formula does not have a differential effect on the way traditional cooking fuel is being used in most parts of the country, largely due to poverty in the majority of the states (Eroke, 2012), and corruption in the entire country, as noted by Omotoso (2010). It is therefore easy to see how mismanagement and corruption, unemployment and poverty compound the effects of irregular supply of fossil fuels, which increase the likelihood of fuelwood use in most parts of Northern Nigeria.

6.6. Chapter Summary, Critique and Conclusion

6.6.1. Chapter Summary

This chapter explained patterns of cooking fuel consumption and distribution in Nigeria. It added to the findings of previous chapters and the existing literature by analysing the high dependency on the use of fuelwood in some parts of the country. It has provided some answers to the two specific questions posed at the outset (see section 6.3.3):

- 1) What factors are responsible for the differences in the use of cooking fuels among the various states of Nigeria?

The findings of this chapter revealed that the majority of the northern states of Nigeria predominantly use fuelwood for their cooking, while their southern counterparts use modern fuels. However, while there is a limited supply of modern cooking fuel in the country, the used of fuelwood in the majority of the northern states is related to the low supply of fossil fuel in the region.

The results of the GWR also confirmed that those states with a high supply of fossil fuels are less likely to be using fuelwood. Similarly, attainment of high average levels of

²¹ Omotoso (2010) argued that poverty, like in the other parts of the country, is more evident in the Niger Delta, even with their 13% revenue allocation, largely due to being mismanaged by the various SG.

education does not necessarily result in a reduction in fuelwood use. The results of the GWR also revealed that the relationships involved in fuelwood usage did not vary much among the majority of the states in the country as might be anticipated.

2) Why are there differences in the fossil fuel supply among the various states?

No clear answer has been found as to why there is a substantial difference in modern fuel supply, which favours a few states in the country. It has however, been found that revenue allocation (South-South receives the highest revenue among SG, but receives a lower fossil fuel supply than South-West), population size and industrial activities do not explain the reasons for the high or low supply of modern fuels in the country.

6.6.2. Chapter Critique

The data used in this analysis were generated some years ago (prior to the removal of the fossil fuel subsidy in January 2012), and may therefore not reflect the current situation in the country in terms of the distribution of fossil fuel and the relative inaccessibility of the product to the people. However, it can be argued that the increase of fossil fuel pump prices following the fossil fuel subsidy withdrawal, aggravated the suffering of the mass of the country's population who cannot afford the necessities of life (because of the increase in the prices of commodities, as a result of the country's reliance on road transport services). In this sense therefore, even the fuelwood consumption figures presented in this chapter may not necessarily reflect the current consumption situation (refer to chapter 8 for a results of the survey conducted in the study area, where the majority of the households mentioned the high cost and unreliability of supply as factors hampering their use of fossil fuels).

Another issue is the scale (state level) at which the investigation was necessarily conducted. The varying sizes of the states considered in this analysis may have concealed localised but important differences, which have therefore not been identified and reported. However, the use of the state boundaries rather than LGA boundaries (which were provided by the census data) was a result of the unavailability of fossil fuel distribution information at a similar scale to the census data, despite several requests to the authorities to provide data at this level of disaggregation (refer to chapter 5: 5.1 for more details).

6.6.3. Conclusion

The results of this chapter show that both modern and traditional cooking fuel types are widely used in Nigeria, although to widely varying degrees. The northern states for example, are deprived of modern fuel supply and are therefore more dependent upon the traditional fuels for their cooking. This of course has implications for cooking fuel poverty, emanating from the fossil fuel supply strategy, which is precarious in the country.

While it has long been recommended that the use of fossil fuels in Nigeria should be encouraged over traditional fuels among households (Sambo, 2008a), this study has shown that the insufficient supply of fossil fuel in the north is causing most households to descend the energy ladder back to the use of fuelwood. For example, as highlighted in chapter 2: 2.5.1.2 and figure 6.6 in section 6.3.2 of this chapter, the use of gas for cooking is still seen in Nigeria as an opportunity to display the level of one's affluence (due to its high cost). It is therefore only popular with the rich people, that have a small family of less than eight members (see more discussion in chapter 8: 8.1(i) & 8.3.2.1). This explains why it has not been a very popular cooking fuel option among many families.

The current situation with modern fuel in Nigeria is expected to worsen in the future due to the recent price increases of PMS and LPG (as a result of subsidy withdrawal), which will make them too expensive for most families to use. Balouga (2012, p.34) noted that there is a lack of *“coherence and consistency in the enforcement of government policy in the household energy sector, which has resulted to the high demand for fuelwood in Nigeria in recent times”*. Unfortunately, the future supply of fuelwood in Nigeria (particularly the northern region) is unsustainable, because the country's forest resources are fast decreasing (FAO, 2010a & b & FAO, 2011b; & local study reported in chapter 4). Therefore, unless there is a change in the existing policy of fossil fuel distribution and pricing, the mass return of households, to the use of fuelwood and charcoal for cooking will continue (Balouga, 2012).

Even though the findings of the GWR revealed that improved supply of modern fuel would reduce fuelwood consumption in the medium/long-term, as things stand, fuelwood will remain the preferred cooking fuel option for the majority of the families, for a very long time to come. As accessible areas of forest decline, especially in northern

states (see chapters 4 & 9), it is inevitable that fuelwood will progressively extend beyond local borders.

GWR has not previously been used in this kind of study; however, it has demonstrated its relevance as an exploratory tool. The findings have been relatively successful in explaining the variation of fuelwood consumption in Nigeria. The method can be particularly effective in this kind of study, because of its ability to identify regional variations in operation of more general processes. The national situation of fossil fuel supply is now clear. The south region, where extensive forest vegetation exists, is well supplied while the northern region (with its savanna vegetation) receives less and uses more fuelwood than the south. It is now important to investigate the situation further in order to understand if the national picture is mirrored by a more local case study. The next three chapters explain firstly, the methodological approach adopted for such a study of factors affecting fuelwood consumption, followed by the results of that study in the subsequent chapters.

Chapter 7: Methodology (Local Causes of vegetation Changes: Field Data Collection & Analysis of Survey Data)

7.1. Introduction

This chapter emanates from the discussion of vegetation change as observed in the Remote Sensing (RS) analysis of the study area (see chapter 4), and the disparity of modern cooking fuel supply observed in Nigeria (in favour of the south) as well as the high consumption of fuelwood in the north (see chapter 6). The chapter explores the methods adopted in the study of the local (Potiskum and Environs) perception of fuelwood use as part of the complex vegetation decrease observed in the study area (chapter 4). This is essential in the context of the overall study because the result will help our understanding of some of the issues facing the people as regards fuelwood use by allowing them to reflect on their experiences through their various responses. The contents of this chapter will assist in achieving the following research objectives (chapter 1: 1.1);

- To identify the causes of the vegetation changes observed in the analysed RS Images.
- To highlight the contribution of fuelwood consumption and collection to the vegetation changes observed.
- To identify the socio—economic drivers of fuelwood consumption patterns.

In order to achieve the above objectives, a questionnaire survey method (interview based questionnaire) was adopted (in two forms; face-to-face and telephone), because of the assertion that it is the most appropriate method in this study as against other survey methods (postal, internet and other self-administered surveys) that may typically result to a low response rate, due to the low level of education in Nigeria (NBS, 2009). Also, the wide scale of the objectives of the study, as well as the practical constraints of time and resources that are required to create awareness of the survey requirements among the targeted population (the respondents) is another reason for using the interview based questionnaire.

Two questionnaires are designed separately; one for the families (the households) and the other one for commercial fuelwood traders (the fuelwood vendors). Therefore, the chapter is structured into two main sections: the first section discusses the households' surveys (section 7.2) and the second section discusses the vendors' survey (section 7.4).

The two sections are each structured into three sub-sections, which highlight the methodology adopted; the choice of the respondents for the survey; and the development and administration of the survey and the data analysis approach. Through these two surveys, a number of important issues relating to fuelwood situations in the study area are reported and the results are discussed in chapters 8, 9 and 10.

7.2. Household Survey

What constitutes a household and a family?

Thomas (2012) argued that a household consists of one or more persons living in the same house or apartment. They may either be related or not. On the other hand, a family has two or more members who live in the same house and are related by birth, marriage or adoption (Thomas, 2012). While all families are also households, not all households are families (non-family households). With this obvious distinction, this research assumed that all households are families, because all the households surveyed (see section 7:7.2.4-7.2.5) indicates that they live as a family (see results in chapter 8:8.1a). Polygamy is also a cultural norm in the study area and the Head of the Household (HoH) is mostly the husband, whose permission is also required in order to gain access to his household (refer to chapter 1:1.4.2 for more detail). The researcher being a male meant that I am unable to speak to the women. However, my view (positionality) is that the HoH interviewed do not compromise the findings of this study since they all have a good overview of the household expenditure. Hence the reason why this research only focussed on interviewing the HoH (male), despite having full knowledge of women's role in cooking meals for the family.

7.2.1. Aims of the Household Survey

The aim of the household survey was to provide data to answer the following research questions (see chapter 1: 1.1.2), which were set out to address the objectives highlighted in section 7.1 above:

- a) Does seasonal or protracted fuelwood scarcity have significant socio-economic effects on households?
- b) What is the relationship between fuelwood consumption and the availability and prices of petroleum products?

7.2.2. Interview Schedule as a Research Technique

Most of the studies that explored social energy relationships in the past have used social surveys as a source of research information. Among the numerous social survey options available, an interview based questionnaire/interview schedule (both face-to-face and telephone (conducted out of necessity- see section 7.2.5.2 for a full discussion)) was considered the most appropriate method to provide both quantitative and qualitative (mixed method) data for this kind of study (Winchester, 1999 & Robson, 2011). The design, control, advantages and limitations of interview schedules have been discussed extensively by many authors which include among others; Benard (2000) and Robson (2011). Below is a summary of some of the advantages and disadvantages of the interview schedule conducted in this study as presented by Robson (2011, pp. 240-242).

❖ Advantages of the interview schedule

- To provide a relatively simple and straightforward approach to the collection of information about the respondent characteristics.
- The interviewer can clarify questions that might not necessarily be understood by the respondents. This is of particular importance in this study because the respondents prefer to speak in their native lingua Franca (Hausa language), which the interviewer can also speak fluently.
- The presence of the interviewer encourages participation and involvement.

❖ Disadvantages of the interview schedule

- The attitude of the respondents towards answering the questions might not necessarily reflect their real identity. For example there is likely to be a social class response bias (impressing the researcher by disguising their real identity).
- The response might be influenced by the interaction of the interviewer/ respondent social class. For example, whether they are of the same or a different class or ethnic background might influence the kind of response.

7.2.3. Household Questionnaire Design

Designing a questionnaire can be a robust procedure that requires careful consideration of the research questions. The model of the survey data collection presented in figure 7.1 below revealed some of the tasks of the researcher in designing a questionnaire that will

reflect the research objectives. The model also presents the collective responsibilities of the researcher as well as the interviewer (who may not necessarily be the researcher himself) and the respondents in working together in order to achieve a valid measure of the research questions. For a more detailed explanation of the process of designing a questionnaire refer to Robson (2011, pp. 252-258).

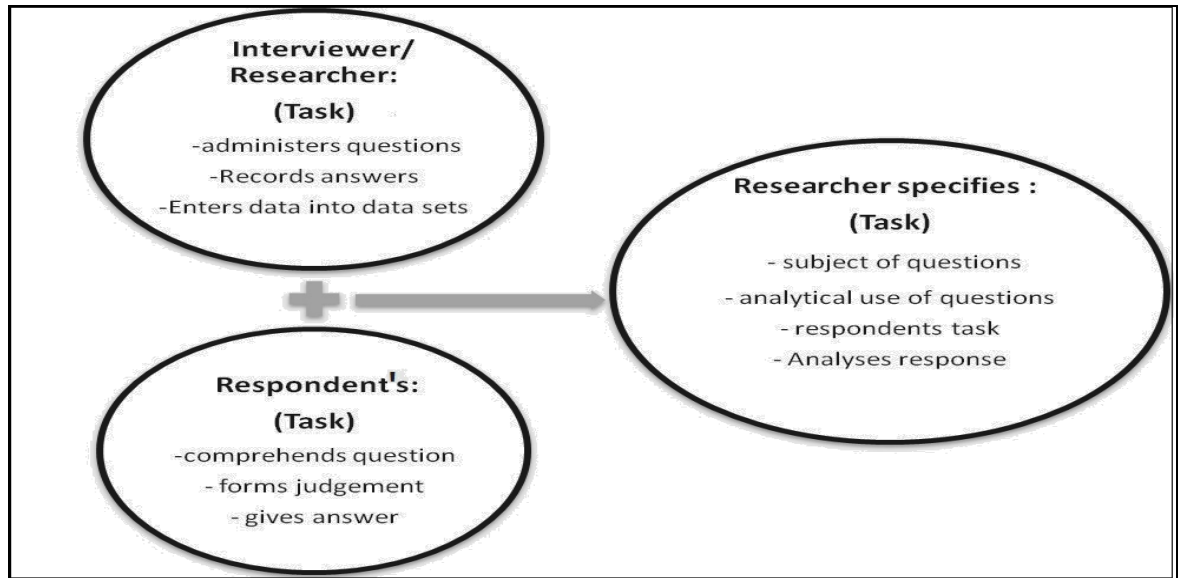


Figure 7.1: Data Collection Process (Survey Model)

Source: Modified from Robson, (2011 p. 252).

The questions in this study were carefully designed to address the research questions highlighted in section 7.2.1. The questions (see appendix 1) were designed in four sections as follows: A. details about the households (family profile); B. Questions about family use of fuelwood (Traditional cooking fuel); C. Questions about family use of fossil fuel (Modern cooking fuel) and; D. Questions about environmental awareness (deforestation). The four sections covered 23 questions in the following formats; closed format (dichotomous and multiple choices), and open format (open questions that require respondents' views). These formats were chosen in order to gather as much information on the general feelings of the respondents regarding fuelwood and to allow them rate specific issues of variability associated with the activities in question. The number of open ended questions was kept to a minimum in the schedule. Only four open ended questions (appendix 1- sections B and D) were asked in the questionnaire. This is because, the use of many open ended questions in an interview schedule is often discouraged (Robson, 2011) especially if the time for the completion of the questionnaire is small (Potts, 1999). However, some of the questions that require further explanations under each of the four sections of the questionnaire were provided with an additional

option for doing so. Each of the four sections has been designed systematically for easy navigation of the questions in the survey in order to avoid duplication of questions.

7.2.4. Households Pilot Survey

The final draft questionnaire was pre-tested in May 2010 (prior to field visit) among colleagues and friends, in accordance with Robson's (2011) advice. After the pre-testing, several questions were edited to improve their clarity and understanding. After the pre-testing of the questionnaire outside the study area, a pilot survey was also conducted in the study area between 12th and 15th July, 2010. The pilot survey was undertaken in an attempt to ensure the optimal way of administering the questionnaire as well as testing the clarity of the questionnaire in the study area (since the questions were to be interpreted by the researcher in the native Hausa language).

Stratified random sampling was used to choose the respondents during the pilot survey, where one of the study areas (Potiskum town) was divided into four major units based on polling unit level (electoral unit divisions- INEC, 2011). Five respondents were randomly selected from each of the four major divisions during the pilot survey. The stratified random sampling was considered a reliable method because according to Robson (2011, p. 272) for a given sample size, the mean of stratified random samples are likely to be closer to the population mean especially if there is little variation in the characteristics of the measured variables. Although, the household population in Potiskum is quite large (34,583- NPC, 2009a), their variation in terms of fuelwood usage for cooking is small (NPC, 2010). The pilot survey was administered face-to-face to the selected households. However, the pilot survey administered in the selected areas as mentioned earlier, failed to provide any meaningful outcomes in terms of response, as only five out of the twenty households selected through the stratified random method responded to the questionnaires (see table 7.1). Interestingly, all the five households that responded to the questionnaire understood the questions clearly. For that reason, the researcher opted for a random sample selection (Robson, 2011) in the main survey.

Table 7.1: Response Rate from Household Pilot Survey

	Number	Percentage (%)
Total administered	20	100
Total responses	5	25
Total declined responses	15	75
Total Invalid responses	0	0
Total Valid responses	5	25

7.2.5. The Main Household Survey

The respondents for the main survey were selected randomly (by visiting as many households as possible in the four major electorate divisions highlighted earlier) with no regard to any probability in the selection process. Therefore, the selection of the respondents was by chance, and only households that showed interest in responding to the questionnaire were interviewed. This kind of sampling was referred to as “convenience sampling” which Robson (2011) described as the most widely used but the least satisfactory method of sampling. The main survey was administered in two formats: face-to-face interview and telephone interview.

7.2.5.1. The Face-to-Face Interview

The Face-to-Face interview was administered between 3rd August and 10th September, 2010 in Potiskum. The proposed target number of the respondents was around 120, but only 72 responses proved satisfactory even though about 75 households responded to the interview. The number of valid respondents dropped from 75 households to 72 because three were not considered (because they answered only three questions out of the 23 questions on the questionnaire- see table 7.2 below). This gives a response rate of 60% of the target. The average time for completion of each questionnaire was about 20 minutes.

Table 7.2: Response from Face-to-Face Survey

	Number	Percentage (%)
Total administered	120	100
Total responses	75	62.5
Total declined responses	45	37.5
Total Invalid responses	3	2.5
Total Valid responses	72	60

7.2.5.2. The Telephone Interview

A telephone interview was conducted to supplement the response rate after the initial 72 valid responses were studied. The telephone interviews were achieved using a similar questionnaire in appendix 1, but were administered in a different location than Potiskum but also within the study area. The interview was conducted in Nangere town, which is the second most important administrative town after Potiskum in the study area.

Nangere town was chosen in order to disseminate the survey across the study area and to avoid possible biased outcomes due to the non representation of responses from other locations within the study area. It is worth mentioning at this stage that the telephone interview was conducted out of necessity because of my inability to travel to the study area in January, 2012 as originally scheduled (as part of the research plan). This was due to insecurity (Boko Haram crises) and the state of emergency enforced in the study area by the government (for more detail, refer to chapter 6, box 6.1). The telephone interviews were conducted using a hired staff (research assistant (RA) – suitably qualified with a Higher National diploma certificate of education). The work of the RA was to make initial contact with the respondents and explain the purpose of the interview to the residents. The RA liaised with the respondents in the evening when the heads of the families returned from their various places of work. If members of the household consented to give the interview, then the RA conveyed that information to me and I was able to call the household and deliver the questionnaire via the telephone. Answers were recorded using a recording instrument in addition to writing the comments on a paper (copy of the respective questionnaires). This was achieved from March, 2012 to May, 2012. The target sample size using this method was 80. The sample of eighty was chosen in order to raise the figure of the respondents from 72 (obtained using Face-to-Face interview) to about 150. However, only 65 households were covered (responded), while 9 questionnaires out of the 65 covered were cancelled because they could not finish answering the questionnaire due to telephone network failure. Also, about 15 households declined to answer the questionnaire. This gives a total response rate of 70% of the original target of 80 households (see table 7.3 below).

Table 7.3: Response from Telephone survey

	Number	Percentage (%)
Total administered	80	100
Total responses	65	81.2
Total declined responses	15	18.8
Total Invalid responses	9	11.2
Total Valid responses	56	70

The average time for completion of each questionnaire was about 30 minutes. This brings a total of about twenty eight hours (1,680 minutes) of phone call excluding the time of the call made for other protocols and negotiations.

7.2.6. Overall household survey response rate

The overall valid percentage of the responses based on the total two hundred questionnaires administered in the two surveys is 64% (see table 7.4 below).

Table 7.4: Overall Total Response from the Household Survey

	Number	Percentage (%)
Total administered	200	100
Total responses	140	70
Total declined responses	60	30
Total Invalid responses	12	6
Total Valid responses	128	64

Although there is no clear convention of an acceptable response rate to validate survey based research, most researchers considered the minimum of 60% to be a reasonable response rate (Robson, 2011). Therefore, the 64% obtained at the end of the survey is considered good enough to provide a representative response outcome due to the homogeneity character of the households (NPC & ICF Macro, 2009 & NPC, 2009b).

7.2.7. Limitation of the Survey Response

The telephone interview is now gaining relevance because according to Robson (2011, p. 263) *“it provides a means of capitalizing on many of the advantages of the interview-based surveys while reducing the time and resources involved in running face-to-face interviews by cutting out the travel requirement”*. Although both telephone-based interviews and face-to-face interviews were used in this survey, they both share similar advantages and disadvantages as described earlier in section 7.2.2.

Overall, it is worth highlighting at this stage that a number of issues were associated with the survey methods. The major limitation being that the samples obtained from the population (in this survey) were not drawn using any form of statistical probability. Robson (2011, p. 140 & 277) questioned this kind of approach by highlighting the over-reliance on the method by many researchers. He however suggested the use of an alternative method to the statistical generation of sample size using a *“theoretical generalization”*. Using the theoretical generalization approach as against the statistical approach, the samples can be selected based on generalized concepts or theories about the population. Interestingly, while selecting the sample size out of the population, this study considered that the majority of households in Nigeria use fuelwood for their

cooking (Sambo, 2009). This consideration reduces the risk of violating the hierarchical order (statistical approach) of the population selection since our interest in the study is to explore the pattern of fuelwood use among the households.

Another issue is with the design of the questionnaire which seeks to ask respondents' opinions on many issues, which might be thought to have an impact on the role of vegetation decrease and fuelwood use in the study area. This has resulted in having so many varied opinions on some issues particularly where the respondents were asked to specify further on the options they choose or where the questions are open ended. Although this might be seen as an advantage rather than a limitation (because it provides an opportunity for the respondents to open up and share their views), it was however time consuming to collect these opinions during the interview and processing of the information took a great deal of time (Robson, 2011).

Nevertheless, all the limitations highlighted above do not in any way invalidate the findings of this study but should be taken into consideration when analysing and interpreting the results (Potts, 1999, p.139).

7.2.8. Data Storage and Processing

Initial data entry and storage involved the use of Microsoft Office Excel, where all the responses were recorded and handled. The statistical software SPSS for windows (version 18.0) was used for the analysis because it provides a better means of analysing the data.

The data were coded (Robson, 2011) using SPSS for easy interpretation and analysis. The analysis uses cross tabulation, stratified cross tabulation, chi-square statistical analysis, and logistic regression modelling to explain some of the patterns of fuelwood usage among households in the study area.

7.2.9. Household Survey Data Analysis

Prior to the commencement of the analysis, the data were coded (Robson, 2011, p.266 & Saldaña, 2009) (see table 7.5 and full discussion in – section 7.2.9.1.). The analysis then proceeded in three stages:

- First the relationships between fuelwood use (dependent variable; Households using fuelwood- FU) and the other response variables obtained from the household interview

(the independent, categorical or predictor variables) were explored using tabular analysis in order to provide an initial impression of the response data structure. The independent variables are; Number of people in household (THN), employment status (Emp), job type (JT), monthly income (Mol), fuelwood procurement process (FP), money spent on fuelwood purchase (MSFW), seasonal variation in the price of fuelwood (SVFP), distance to fuelwood procurement centre (DFP), access to preferred fuelwood type (APFT), households using charcoal (CU), charcoal procurement process (CP), seasonal variation in the use of fuelwood (SVFU), quantity of fuelwood use (QFUW), households using alternative cooking fuel types (OCTU), types of alternative cooking fuel used (LOCT), obstacle to the use of alternative cooking fuel types (AOCTU), households willing to switch to the use of alternative cooking fuel types (WiOCT) and environmental awareness of deforestation (VegCh). This was followed by testing the strength of the relationships using chi square analysis (see section 7.2.9.3). The results are presented in chapter 8:8.1.

The second stage of the analysis involved the exploration of the relationships of the various responses in order to identify if there are any compounding effects between them. This was achieved using cross-tabulation stratified percentages (refer to section 7.2.9.4 for detail). In determining the compounding effects between the responses, three variables (FU, VegCh & WiOCT) are considered as the dependent variables, each with its potential predictor (independent variables – refer to table 7.7 below for detail).

- The third stage of the analysis statistically test the results of the relationships obtained in stage two, by considering the possibility of interaction effects between some of the dependent variables (refer to table 7.7) and their respective predictor variables using logistic regression (refer to section 7.2.9.5 for detail).

The combination of the resulting outcome of these three stages of exploration (presented in chapter 8) provides some answers to the questions raised in section 7.2.1.

Table 7.5: Households' Interview Coding

Column Headings	Labels	Codes	Response					
			Valid		Missing		Total	
			Count	Percent	Count	Percent	Count	Percent
THN	Number of people in household	1 = ">6"; 0 = "< 6"	128	100.0%	0	.0%	128	100.0%
Emp	Employment status	1 = "Employed" ; 0 = "Unemployed"	128	100.0%	0	.0%	128	100.0%
JT	job type	1 = "Civil Servants & others" and 0 = "Farmers"	108	84.4%	20	15.6%	128	100.0%
Mol	Household monthly income	1 = "Low wage" 2 = "Minimum Wage" and 3 = "High Wage"	105	82.0%	23	18.0%	128	100.0%
FU	Households using fuelwood	0 = "No" and 1 = "Yes"	128	100.0%	0	.0%	128	100.0%
FP	Fuelwood procurement process	1 = "Buying always" 2 = "Buying Sometimes" and 3 = "Self procurement"	112	87.5%	16	12.5%	128	100.0%
MSFW	Money spent on fuelwood purchase	1 = "<1800 Naira" ; 2 = "1800_3000 Naira" ; and 3 = ">3000 Naira"	105	82.0%	23	18.0%	128	100.0%
SVFP	Seasonal variation in the price of fuelwood	1 = "Rainy Season" ; 2 = "Cool Dry Season (Harmattan)" and 3 = "No Difference"	98	76.6%	30	23.4%	128	100.0%
DFP	Distance to fuelwood procurement centre	1 = "Market < 1 KM" ; 2 = "2_5 km" and 3 = "> 5 km"	97	75.8%	31	24.2%	128	100.0%
APFT	Access to preferred fuelwood type	1 = "Yes" and 0 = "No"	110	85.9%	18	14.1%	128	100.0%
CU	Households using Charcoal	1 = "Yes" and 0 = "No"	126	98.4%	2	1.6%	128	100.0%
CP	Charcoal Procurement	1 = "Buying" and 2 = "Self Making"	62	48.4%	66	51.6%	128	100.0%
SVFU	Seasonal variation in the use of fuelwood	1 = "Rainy Season" ; 2 = "Cool Dry Season (Harmattan)" and 3 = "Hot dry Season"	111	86.7%	17	13.3%	128	100.0%
QFUW	Fuelwood Quantity use	1 = "< 100 Kg" and 2 = "100 -249 Kg" 3 = ">250 Kg"	99	77.3%	29	22.7%	128	100.0%
OCTU	Using additional cooking fuel type	1 = "Yes" and 0 = "No"	124	96.9%	4	3.1%	128	100.0%
LOCT	Additional cooking fuel Type	1 = "Kerosene" ; 2 = "Electricity" ; 3 = "Kerosene and Electricity" and 4 = "Kerosene, Electricity and Gas"	71	55.5%	57	44.5%	128	100.0%
AOCTU	Obstacles other cooking fuel	1 = "Yes" and 0 = "No"	112	87.5%	16	12.5%	128	100.0%
WIOCT	Household cooking fuel choice (switching to the use of modern fuel)	1 = "Yes" and 0 = "No"	126	98.4%	2	1.6%	128	100.0%
VegCh	Environmental awareness1	1 = "Yes" and 0 = "No"	125	97.7%	3	2.3%	128	100.0%

NOTE:

All missing values= "9"

£1.00 = 250 Nigerian Naira.

The new national minimum wage in Nigeria is 18,000 Naira

7.2.9.1. Coding the Questionnaire Respondents Responses

The result of the interview was coded and the resultant codes stored in SPSS. Table 7.5 contains a summary of the results. A missing value in the result is coded as 9. Some of the codes in the table were assigned after transforming the respondent's information. For example, questions 7 and 15 in section B (appendix 1) require the respondent to give a weekly account of their fuelwood spending and approximate quantity used because of the assertion that one week is reasonable enough (easy) for the respondents to recall their expenditure on fuelwood. These responses were subsequently converted to months (by multiplying the response value of each household (figures) by 52 (weeks in a year) and dividing the result by 12 (months in a year)) in order to comply with the rest of the questions during the analysis and results interpretation. Using the codes achieved in table 7.5, the data exploration commences as demonstrated in the subsequent sections.

7.2.9.2. Cross-Tabulation

Cross-tabulation involves the counting of the codes from one variable and comparing them with the codes in a second variable (Robson, 2011). Cross-tabulation was used in exploring the household's responses (data). This was achieved by testing the various responses (see stage 1 in section 7.2.9) against the dependent variable of fuelwood consumption (FU). The main reason for adopting this approach of data analysis was to explore the pattern of fuelwood use among different characteristics of resident's responses.

The major problem with cross-tabulation is when the variables have too many values, which can make the interpretation and computation of statistical tests more complicated (for more detail, see- Landau & Everitt, 2004). This was avoided here (see table 7.5) because the codes were kept as simple as possible by trying to avoid any distortion of the original information provided by the respondents.

The results of the relationships achieved using the cross-tabulation is presented in chapter 8.

7.2.9.3. Chi Square Analysis

Chi-square analysis was used in testing the statistical significance of any associations between the dependent and the independent variables in the cross-tabulation (see stage

1 in section 7.2.9). For more detail on the chi square analysis, refer to Ebdon (1985). The chi-square statistics was calculated as follows:

$$\chi^2 = \sum \frac{d^2}{e} \quad \text{Equation.....7.1}$$

From equation 7.1, χ^2 is the symbol for chi square, d is the difference between the observed and the expected frequency for each category, and e is the expected frequency of each category. The chi square analysis conducted here uses a statistical significance level of 0.05 (1-tail or 1-sided).

However, the calculation of chi square analysis is faced with many rules or restrictions (Ebdon, 1985 & Field, 2009). One such rule, apart from the basic requirement that the data have to be in frequencies before the calculation can be considered valid is that the frequencies in the categories should not be small. For example, if there are two or more categories, no more than one fifth of the expected frequencies should be less than five.

One way of addressing the issue that was also used here (after the initial exploration of the data revealed that some of the categories' frequencies were less than five), was to report the Fisher's exact test (Field, 2009) instead of the chi square test result. Fisher's exact test compute the exact probability of the chi square statistics that is accurate when sample sizes are small (for more detail, refer to Field, 2009, p. 690). Also, the main issue with the Fisher's exact test is that it only works in a 2x2 table category where the two variables in the table have two options each (see example from table 7.6 below).

Table 7.6: An Example of a 2x2 Fisher's Exact Test Table

		Employment Status		Total
		Employed	Unemployed	
Households using fuel wood	No	7	6	13
	Yes	105	10	115
Total		112	16	128

For that reason, those categorical variables that have more than two categories in their codes (THN, Mol, FP, MSFW, SVFP, DFP, SVFU, QFUW and LOCT- see table 7.5 above) were re-examined based on their initial frequencies obtained (see section 7.2.9.2 above).

The following null hypothesis was tested using the Fisher's exact statistical test:

H0- The various explanatory variables (section 7.2.9) are not indicators of fuelwood use among households in the study area.

The results of the Fisher's exact test were further tested using the Phi test in order to verify the strength of the result. Phi (ϕ) is calculated using the equation below (Field, 2009).

$$\phi = \sqrt{\frac{\chi^2}{N(k-1)}} \quad \text{Equation7.2}$$

From equation 7.2, N is the total number of the samples, and k ($k=2$) is the number of the rows and columns in the data table, while χ^2 is the exact value of the test without any correction. The phi results measures the value of the association between the dependent and the independent variables. The strength of the association is measured on a scale of 0 to 1 as follows: greater than 0.5 high associations; 0.3 to 0.5 moderate associations; 0.1 to 0.3 low association; and 0 to 0.1 little or no association.

However, it is worth noting that the testing of the association (ϕ) can only be interpreted if the chi-square statistic shows a statistical significance (i.e. it doesn't make sense to say there is a strong relationship between two variables when the statistical test shows this relationship is not statistically significant).

7.2.9.4. Stratified Cross-Tabulation

The stratified cross-tabulation is similar to the cross tabulation explained in section 7.2.9.2 above. The only difference between them is that while cross tabulation uses two variables; one dependent and one independent, the stratified cross tabulation uses more than one independent variable to explain the dependent variable in question (Field, 2009). The stratified cross tabulation investigates the association of the responses (data) under the following themes: fuelwood use (consumption) - FU; environmental awareness (deforestation) – VegCh and switching to other alternative sources of cooking fuel- WiOCT (table 7.7). The reason for selecting these variables as the predictors of their respective dependent variables was because of their characteristics of being able to address some of the research questions (refer to section 7.2.1). The results of these explorations are presented in chapter 8: 8.2.

Table 7.7: Stratified Cross-Tabulation Variables

Dependent variables	Independent variables
a) FU-	THN and JT
b) VegCh –	FP, APFT and ES (Emp, JT and MOI
c) WiOCT –	OCTU, AOCTU, Emp and THN

7.2.9.5. Logistic Regression

In addition to the exploratory approaches executed via stratified cross-tabulations, logistic regression was used to investigate the relationship between the outcome variables (FU, VegCh and WiOCT) and each of the dependent variables whilst controlling for all other independent variables (see table 7.7 above). The choice of logistic regression as against other kinds of regression methods such as discriminant function analysis (DFA), linear or multiple regression models is because, the response variable (see table 7.5 above) is binary (nominal) for example, 1 or 0 (yes or no) rather than continuous or a mixture of the two (see Field, 2009 for more detail). Logistic regression calculates the probability of success (1) over the probability of failure (0) which is one of the advantages of logistic regression. For example, taking one of the binary categorical values 1 or 0 in table 7.5 above, the expected value is simply the probability, (p), that the variable takes the value 1. Therefore, applying other regression methods for this kind of probability test could lead to predicted values of the probabilities outside the interval binary values (Landau & Everitt, 2004)²². The approach in logistic regression is the modelling of the predicted probability value, p, indirectly via what is known as the logistic transformation of (p) or logit (p) (Landau and Everitt, 2004). Logistic regression is calculated as follows:

$$\text{logit}(p) = \ln [p / (1-p)] \quad \text{Equation... 7.3}$$

Or

$$p = \frac{\exp(\beta_0 + \beta_1 x_1 + \dots + \beta_q x_q)}{1 + \exp(\beta_0 + \beta_1 x_1 + \dots + \beta_q x_q)} \quad \text{Equation... 7.4}$$

From equation 7.4, p is the probability that a case is in a particular category; \exp is the base of natural logarithms; β_0 is the constant of the equation; and, $\beta \dots$ are the respective coefficients of the predictor variables.

The computation of the logistic regression was undertaken in SPSS statistical software for Windows. The Stepwise method of entry was used in computing the logistic regression

²² In summary, the logistic regression provides a linear model for a suitable transformation of the expected value of a response variable and therefore allows for only the binomial error distribution, as against other regression models that may yield to a variety of different error distributions (Chapter 24 Logistic Regression, n.d & Landau & Everitt, 2004, pp.222-223). For more detail on logistic regression refer to Landau and Everitt (2004); Agresti (2007); Field (2009) & Paulant (2010).

because the study is for exploratory purposes (Field, 2009). The stepwise method of entry is considered optimal in a situation where there is no previous research or theory that exists on which to base the hypothesis for testing the results (Field, 2009). This is particularly relevant to this study where the investigation only tries to find a relationship between events (see table 7.7 above). The stepwise method was chosen using the forward LR method in SPSS (Field, 2009, p.272). The advantage of this entry method is that it uses the likelihood ratio test (chi-square difference) to automatically add the variables with the most significant statistics score into the model (Field, 2009). The results are presented in chapter 8.

7.3. Ethical Consideration

The interviews conducted in this study involve talking to adults and therefore, there is an ethical requirement to provide sufficient explanation to respondents regarding the rationale for the study. In addition, the study subjects need to provide consent information and they also need to know that they can find out about the results of the study if they so wish. It was against this background that an introductory note and a consent agreement (participant information sheet) were read out to the respective respondents (see appendix 3 for a copy) before the interview. The participant information sheet emphasised that all the information given by the respondents will remain anonymous and will only be used for the research purpose, and that they may refuse to answer any of the questions and even quit the interview at any point. The information sheet also indicated that all the information they presented would be available via the final thesis document.

7.4. Interview Schedule Continued (Fuelwood Vendors)

7.4.1. Aims of the Fuelwood Vendors Survey

In an attempt to get information about the commercial activities of fuelwood in the study area, a questionnaire was designed for the commercial fuelwood vendors, in a similar format to the household questionnaire described in section 7.2.3. The aim of the survey is to find answers to some of the research questions originally posed in chapter 1: 1.1.2. Therefore the commercial fuelwood vendors' survey addressed the following research question:

a) If fuelwood is one of these causes of deforestation, how is it being procured and distributed in the study area?

In order to answer this question, the following sub-questions emerged and are addressed here (refer to chapter 9 for results):

- What are the activities involved in fuelwood procurement? In other words, what type of tools and labour are used in the acquisition process, and how far do they travel in order to meet the high demand of fuelwood?
- What season of the year is mostly dominated by the activities of fuelwood and why? Is there any seasonal component to fuelwood demand and price?
- What determines the price of fuelwood in the study area?
- What is the structural system/chain of activity in the commercial fuelwood industry? How is the industry in terms of organisation?

7.4.2. Questionnaire Design

The questionnaire was designed to address the research questions above (section 7.4.1). The questions (see appendix 2) were designed to cover the following three sections: a. Facts about fuelwood business; b. Facts about fuelwood procurement process and pricing; and c. Organization of fuelwood business in a typical year and suggestions for improving the industry. The three sections covered 17 questions in the following formats: closed format (questions 1 and 9, which ask the respondents to respond to either yes or no options), and open format (open questions that require respondents to explain or specify further). The dominance of open ended question formats in the questionnaire was to gather as much information as possible, on the general activities of commercial fuelwood and to allow the vendors to elucidate on issues associated with their activities. However, as identified earlier (section 7.2.3), the use of many open ended questions in an interview schedule faces the disadvantage of requiring a substantial amount of time for the completion and analysing of the information. The three sections of the questionnaire were designed systematically in order to avoid duplication of questions during the survey.

7.4.3. Pilot Survey

Again like in section 7.2.4, the designed questionnaire was pre tested prior to the field visit among colleagues and friends, whose constructive comments help in making the final questions more clear and simple. A second pilot survey was also conducted on 19th July

2010 in the study area. This was administered in the native language (*Hausa*), since none of the vendors can understand English.

7.4.4. The Vendors Survey

7.4.4.1. Issues Faced During Vendors Survey (Validation of the Respondents Selection)

Prior to field visit and pilot study, the target sample size for the respondents was fifty, who are to be selected using a stratified random sampling (as explained earlier in section 7.2.4). However, this was not achieved, and instead of administering the questionnaire as planned, the method was changed to a focus group discussion (FGD). The reason for adopting a FGD was that the vendors, were initially (at the beginning of my visit to them on 10th July, 2010), not willing to cooperate with me (suspicious of reporting their activities to the authorities), despite being formally introduced to them as a researcher by one of their key members. I therefore had to re-design my approach by paying them more regular visits. In the process, I began to understand some of their activities through the numerous discussions which I have engaged with them. They consented to give me an interview about one week later (19th July, 2010). Although this was seen as an additional task, given that the time allocated for the research field trip was extended by a couple of weeks. However, Clissett (2008) reported the importance of a prolonged engagement and continual observation of the participants of a study (participant observation). He maintained that by constantly observing the participants, the researcher will have more time to learn the culture and context of the issue he or she is studying. This is essential, because it will also enable the researcher to develop a personal relationship of trust with the participants among other things. On the other hand, without a regular observation and prolonged engagement with the participants, there is the tendency that the researcher might overlook some of the critical aspects of the research (Clissett, 2008, p. 104).

In line with Clissett's (2008) observation which occurred to me during my visits to the vendors, I realised that the vendors operate in large groups, under one leader who acted as their coordinator. I therefore explained to them my initial intention of holding many interviews, but the vendors' "chairman" advice me to go for a group discussion in order to avoid duplication of expression, since they all do virtually similar things. Complying with the advise, I opted to conduct two FGD based on the questions designed in the

questionnaire (see appendix 2). The FGD was conducted with the leaders and a few of their team members. The first interview was conducted with a large group of 10 people (50 people in the overall group) and the second interview was conducted with a small group of 5 persons (7 people in the overall group). This was achieved in Potiskum town between 26th and 27th July, 2010. A further discussion was achieved in Nangere between February and March, 2012 with an additional number of participants (refer to section 7.4.4.2 for detail).

The choice of this strategy enabled me to compare the similarities and disparities in the mode of fuelwood operations and activities between the two different groups. Through their responses, and later collaboration, most of the information required from them was provided to me. They also organised a visit with me to a few fuelwood collection centres. Marshall and Rossman (1999, pp. 114-115) and Robson (2011, pp. 293 - 300) gave a detailed description of FGD, whose advantages and the disadvantages are reflected upon below.

7.4.4.1.1. Advantages of FGD

- The FGD is socially oriented where the respondents and the interviewer interact in a more relaxing atmosphere than the face-to-face interview (Marshall & Rossman, 1999).
- The dynamics of the group help in focussing on the most important topics and it is fairly easy to assess the extent to which there is a consistency in the respondent's views (Robson, 2011).
- The complementation of the FGD with the initial interaction of the researcher with the respondents provided a form of trust and understanding which favour the conduct of the overall exercise (Clissett, 2008).
- FGD is a relatively cheap method of interview that provides a means of getting quick results that are readily understood (Marshall & Rossman, 1999).
- People who are illiterate or who have other specific difficulties are not discriminated in the surveys (Robson, 2011).

7.4.4.1.2. Disadvantages of FGD

- The interviewer has less control over a group interview than a face-to-face interview, which may result in a loss of a considerable amount of time (Marshall & Rossman, 1999).

- Facilitating the interview process requires considerable expertise (Robson, 2011).
- Confidentiality can be a problem between participants when interacting in a group situation (Robson, 2011).
- There is also the logistical problem arising from the need to manage a conversation while getting good quality data (Marshall & Rossman, 1999).

7.4.4.2. The Fuelwood Vendors Telephone Interview

Initial exploration of the two responses (FGD discussed above) provided some interesting information, which upon preliminary analysis, I realised that additional information (interviews) from other towns within the study area is required to supplement the information. I chose Nangere town being the second most important town (administratively) in the study area, after Potiskum. The interviews in Nangere were conducted on 21st February, 2012 and 6th March, 2012 using telephone interview (conference telephone), in a similar techniques earlier described in section 7.2.5.2. The interview was achieved using the same vendor's questions asked in Potiskum (refer to appendix 2). In total, four groups of vendors were interviewed in Nangere town. However, the four groups of vendors that participated were organised on the market days (periodic market of Nangere town which operates every Tuesday). The idea was suggested to me by my RA (see section 7.2.5.2.), because according to him, it was the best day to capture the ideas of the various vendors in the town, since the majority of them come to the weekly market with their goods.

The average time for the completion of each questionnaire was about 40 minutes; this was achieved through the leaders of the groups who answered the questions on behalf of their groups. However, the conduct of the exercise was similar to a telephone conference system, because a few of the group members were also available during the discussion in order to listen and to also contribute to the discussion. This was achieved using speaker phones. The responses were recorded on a recording device and were written down (transcribed) immediately after each interview.

7.4.5. Limitation of the Survey Response

Section 7.2.2 above highlighted some of the problems of interviews in general. However, what needed to be added at this stage is that because of the nature of the questions in

the vendor's questionnaire (open questions), and the sensitivity of the fuelwood business, extra care and attention to detail was required by the researcher. This can be illustrated by the initial uneasiness of the vendors with an outsider (the researcher) as mentioned earlier, which can affect the quality of the information they may give.

7.4.6. Ethical Consideration of the FGD

A similar approach of research ethics considered during the household survey (refer to section 7.3) was implemented during the vendors interview.

7.4.7. Data Storage and Processing

The information collected were transcribed and recorded in a Microsoft Office Excel spreadsheet. The six groups of vendors interviewed provided enough information that requires a careful handling, and further exploration. The processing of the data was therefore, achieved using a qualitative approach given that almost all the information provided by the groups are descriptive in nature.

7.4.8. Pre-Analysis of Fuelwood Vendors Survey

Baxter and Eyles (1997) described the complexity involved in the evaluation and dissemination of the result of a qualitative research to an agreeable standard. They maintained that a common principle adopted by the majority of qualitative geographers is ensuring rigorous description of their presentations and the provision of information on the appropriateness of their methodology. Therefore, a qualitative researcher is faced with the task of providing the audience with a clear research designs, and a transparent discussion in the derivation of their findings (Baxter & Eyles, 1997, p. 506).

Having described how the data for the study were generated in the preceding sections (7.4.2 - 7.4.7), this section describes how the data are analysed. Analysing qualitative data is a multi step approach that involves, "reading through the interview or focus group transcripts and other data, developing your codes, coding the data, and drawing connections between discrete pieces of data" (InSites, 2007, p. 1).

The six groups of vendors that participated in the discussion are presented in the table 7.8 below:

Table 7.8: The Six Groups of Vendors Interviewed

Respondent ID #	Respondent identity	Date Conducted	Group size
1	Group Leader (A) –Potiskum town	26/07/2010	7
2	Group Leader (B) –Potiskum town	27/07/2010	50
3	Group Leader (C) –Nangere town	21/02/2012	20
4	Group Leader (D) –Nangere town	21/02/2012	10
5	Group Leader (E) –Nangere town	06/03/2012	4
6	Group Leader (F) –Nangere town	06/03/2012	5

Having recorded their responses (transcribed), I followed the InSites', (2007) advice of using tables in Microsoft Office Excel to organise the data. This gives me the option of sorting the responses by either using the questions or the respondents' id's, to assess the similarities and disparities of the respondents' responses. See table 7.9 below for an illustration.

7.4.8.1. Data Coding and Analysis (Qualitative Data Analysis)

"A code in a qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (Saldaña, 2009, p. 3). Coding therefore, is a process of reducing the data into smaller groupings for easy handling (InSites, 2007, p. 5). The data coding in this study were achieved by using the thematic form of the questions designed in the questionnaire (appendix 2). An example of the coding approach achieved in this study, is illustrated in table 7.9.

Table 7.9: An Illustration of the Questionnaire Transcripts Coding

ID#	Q#	Response	Code	Code Description
1	1	xxxxxxxxxxxxxxxxxxxx	OB	Second job after fuelwood business
1	2	xxxxxxxxxxxxxxxxxxxx	PRC	Reason for fuelwood business
1	3	xxxxxxxxxxxxxxxxxxxx	NPE	Group size
1	4	xxxxxxxxxxxxxxxxxxxx	LT	Labour division
1	5	xxxxxxxxxxxxxxxxxxxx	DOS	Business organisation
1	6	xxxxxxxxxxxxxxxxxxxx	BP	Profit in the business
1	7	xxxxxxxxxxxxxxxxxxxx	BR	Reason for fuelwood harvesting
1	8	xxxxxxxxxxxxxxxxxxxx	TAX	Tax paid to government
1	9	No	CH	Charcoal selling
1	10	No response	CHS	Source of charcoal sold
1	11	xxxxxxxxxxxxxxxxxxxx	TR	Mode of transporting fuelwood from the procurement centres
1	12	xxxxxxxxxxxxxxxxxxxx	PrD	Distance to procurement centre
1	13	xxxxxxxxxxxxxxxxxxxx	TL	Tools used in processing fuelwood
1	14	xxxxxxxxxxxxxxxxxxxx	PD	Fuelwood pricing strategy
1	15	xxxxxxxxxxxxxxxxxxxx	APA	Business organisation in a year
1	16	xxxxxxxxxxxxxxxxxxxx	ASA	Business organisation in a year
1	17	xxxxxxxxxxxxxxxxxxxx	VS	Suggestions and way forward

The table described the first cycle coding method (Saldaña, 2009, p. 67) used. The codes were derived from the questions in the questionnaire (see appendix 2). This type of coding approach is referred to as structural coding, which Saldaña (2009, p. 67) regarded as an appropriate method for coding an interview transcript.

After initial review of the information from the first cycle coding, patterns began to emerge from the data. From the emergent pattern of information, a second cycle coding (Saldaña, 2009) was adopted in order to amalgamate some of the similar information into a broader concept. For example, responses to questions two (PRC) and seven (BR) were merged into one major idea as both the six discussants appeared to be repeating themselves in the two questions.

Through this way, similarities and differences in the different set of the emerging themes were re-organised and interpreted based on the differences and similarities of the six groups. The result and discussions are presented in chapter 9.

7.4.9. Conclusion

The choice of households and fuelwood vendors in this study is because of their significance of being the respective dominant users and providers of fuelwood energy in Nigeria. As such, their requirements and contributions to the deforestation pressure and resource depletion are directly relevant to this study as earlier highlighted in chapter 2: 2.3.4 and chapter 4: 4.2.4 - 4.2.5.

The next three chapters (8, 9 & 10) present the results and discussions of the survey findings explained earlier in this chapter.

Chapter 8: Fuelwood as a Major Factor in Vegetation Change

8.0. Introduction

The results of chapters 4 and 6 suggest that fuelwood consumption is one of the main factors in the vegetation changes observed in the study area. This necessitates a further exploration of the use of fuelwood among households in the study area (refer to chapter 1: 1.4 -1.4.4 for more details of the study area). This chapter thus presents the results and discussions of the analysis of the household survey described in chapter 7: 7.2.0. The results are presented in the subsequent sections below using tables and graphs, while the discussions follow in section 8.3.

8.1. Investigating Household Influence on the Use of Fuelwood

A number of variables were hypothesised to be the determinants (predictors) of fuelwood use (refer to chapter 7: 7.2.9), and information on these items was collected via the household survey. The coded variables from this survey (the household's responses) were explored via cross tabulations. The resulting outcome of the cross tabulation showing the relationships of each of the variables with fuelwood use are presented in the following order (in table 8.1; a-k):

a) Family Size

Table 8.1a indicates that out of the 128 households that responded to the questionnaire (no missing respondents), the number of households that use fuelwood is 115 (90%).

Table 8.1a: Family Size and Fuelwood Use

		Households using fuelwood		
		No	Yes	Total
Number of people in household	< 6 People	13	36	49
		26.50%	73.50%	100%
	> 6 People	0	79	79
		0%	100%	100%
Total		13	115	128
		10.20%	89.80%	100%
Fisher's Exact Test ^a		Phi Test		
Exact Sig. (1-sided)		Value	Approx. Sig.	
.000		0.427	.000	

^a Computed only for a 2x2 table

In contrast, only about 10% (13 households – all with family sizes of less than 6 people in the households) do not use fuelwood for their cooking. In contrast all households with

more than 6 people use fuelwood for their cooking. From the table, there is an association between fuelwood use and larger households. Furthermore, the phi test shows that this association is statistically significant (refer to chapter 7: 7.2.9.3 for detail). The phi test result (0.43) revealed that there is a medium value of association between the number of people per household and whether the households use fuelwood or not. This value is significant (Fisher's exact test, $p = 0.000$).

b) Employment

Table 8.1b shows the cross tabulation between the employment status of the head of the family and fuelwood use.

Table 8.1b: Employment Status and Fuelwood Use

		Households using fuelwood		Total
		No	Yes	
Employment Status	Unemployed	6 37.50%	10 62.50%	16 100%
	Employed	7 6.30%	105 93.80%	112 100%
Total		13 10.20%	115 89.80%	128 100%
Fisher's Exact Test ^a		Phi Test		
Exact Sig. (1-sided)		Value	Approx. Sig.	
.002		0.342	.000	

^a Computed only for a 2x2 table

The table suggests that there is a greater use of fuelwood amongst those households where the head of the household (HoH) is in employment compared to those households where the HoH is not employed (approximately 94% compared to 6.3%). It must be noted however that there are relatively few households where the HoH is not in employment (16 out of 112).

The phi test result (0.34) revealed that there is a medium value of association between employment status and fuelwood use. This value is significant (Fisher's exact test, $p = 0.000$).

c) Job Type

Table 8.1c shows the relationship between the job type of the HoH and fuelwood use. The table revealed that the job type of the HoH has an influence on the use of fuelwood. However, the variation of fuelwood users with job variation is not great (all the 24 farmers use fuelwood compared to the 92% of the civil servants who use fuelwood).

Table 8.1c: Job Type and Fuelwood Use

		Households using fuelwood		Total
		No	Yes	
Job Type	Farmer	0	24	24
		0%	100%	100%
	Civil	7	77	84
	Servant	8.30%	91.70%	100%
Total		7	101	108
		6.50%	93.50%	100%
Fisher's Exact Test ^a				
Exact Sig. (1-sided)				
.162				
^a Computed only for a 2x2 table				

This relationship is insignificant (Fisher's exact statistical test, $p = .16$). Thus, the job type of the HoH has an insignificant effect on the use of fuelwood.

d) Income

The cross tabulation between the income of the HoH and fuelwood use is presented in table 8.1d.

Table 8.1d: Income and Fuelwood Use

		Households using fuelwood		Total
		No	Yes	
Monthly Income	Low Wage	3	34	37
		8.10%	91.90%	100%
	National minimum Wage	4	64	68
	+	5.90%	94.10%	100 %
Total		7	98	105
		6.70%	93.30%	100%
Fisher's Exact Test ^a				
Exact Sig. (1-sided)				
.474				

^a Computed only for a 2x2 table

N.B. National minimum wage is 18,000 Naira per month

The table highlighted that out of the 105 households that revealed their monthly income, only 7 households (low wage earners- 3 families; national minimum wage and above earners- 4 families) do not use fuelwood. However, this relationship is insignificant (Fisher's exact test, $p = .47$), which suggests that irrespective of the monthly income status of the households, the majority (more than 93%) of the households use fuelwood for their cooking.

The relationship between households' spending on fuelwood and fuelwood use suggests

that the majority of the households spend more than 10% of their monthly income on the purchase of fuelwood. Out of the 105 households that reported their estimated spending pattern on fuelwood, about 19% (20 households) have identified that they spend less than 1,800 Naira monthly (10% of the national minimum wage), which is less than the 81% (85 households) that reported a spending of up to 35% of their monthly income on the purchase of fuelwood (49 households spend between 1,800 to 3,000 Naira, while 36 households spend more than 3,000 Naira).

In response to the question on households' spending on fuelwood purchase in the different seasons of the year, out of the 98 households that responded to the question, more than 71% (70 families) have identified that they spend more during the rainy season. In contrast, 26% (25 families) reported that they spend more during the cool dry season (Harmattan season), while the remaining 3% (3 families) feel no difference in the fuelwood price throughout the year. Overall, 97% of the respondents noticed the seasonal variation of fuelwood prices, with prices soaring in the rainy and harmattan seasons respectively (approximately 5 months; rainy season – July to September and harmattan season- December to January).

e) Method of Fuelwood Procurement

Table 8.1e shows the relationship between fuelwood procurement and fuelwood use.

Table 8.1e: Fuelwood Procurement Method and Fuelwood Use

		Fuelwood Procurement Method			Total
		Always having to buy	Buying Sometimes	Self procurement	
Households	Yes	69	36	7	112
using fuelwood		61.6%	32.1%	6.3%	100%

From the table, out of the 112 households that responded to the question, 105 households buy their fuelwood from the commercial fuelwood vendors in contrast to the 7 households that source their fuelwood using family labour. Although no statistical tests were computed for this relationship because the status of households using fuelwood is constant in this association (SPSS resulting output), the result revealed that the majority of the families purchase their fuelwood. In contrast, only a few households relied on family labour for the procurement of their fuelwood.

The relationship between the distance to fuelwood procurement centres and fuelwood use suggests that out of the 97 households that responded to the question, 55 families

have identified that they obtained their fuelwood from the vendors (normally about 1Km away from their houses). In contrast, about 28 families reported that apart from buying their fuelwood from the vendors, they also travel up to a distance of 5km into the neighbouring forest or to their farmlands to obtain their fuelwood, while only 14 families travel more than 5Km into the neighbouring forest (state owned) or their farmlands to complement their fuelwood requirements. This again revealed that the majority of the families relied on the commercial fuelwood vendors who lived nearer to their neighbourhoods²³.

However, the results of the relationship between access to the households' preferred fuelwood type (i.e. wood species preferred by the households- see section 8.3.3.1 & table 8.3) and fuelwood use reveal that out of the 110 households that responded to the question, about 51% (56 families) have identified that they have difficulty in getting their preferred fuelwood species in recent times, while 49% (54 families) reported that they have access to their preferred fuelwood type. This even variation in the accessibility situation of the households' to their preferred fuelwood choice did not come as a surprise, because the majority of the households purchase their fuelwood from the vendors (see table 8.1e above). However, the vendors are now complaining of increasing distance to procurement centres as well as the constant harassment by the forestry officials as a barrier to their procurement process (see more discussion in chapter 9: 9.2.5 & 9.2.7).

f) The Interaction of Fuelwood and Charcoal Use

Table 8.1f shows the cross tabulation between households that are using charcoal and households' fuelwood use. Out of the 126 families (98%) that answered the question, the majority of the families do not use charcoal for their cooking (69 families do not use charcoal whilst 57 families use charcoal in conjunction with fuelwood). In contrast, only 13 families (10%) do not use fuelwood for their cooking among the total 126 respondents, of which 9 families solely use charcoal, while 4 families (3%) do not use either fuelwood or charcoal for their cooking. However, this relationship is insignificant (Fisher's exact test $p = 0.06$) which revealed that the resulting outcome of the association observed between households that use charcoal or not and households using fuelwood or not, happened by

²³ The vendors are well spread throughout the town, with the main owners or dealers concentrated in the market place. Refer to chapter 9: 9.2.1 for more detail.

chance. Therefore, this suggests that the use of charcoal (without fuelwood) for cooking in the study area is relatively low among households.

Table 8.1f: Households using Charcoal and Fuelwood Use

		Households using fuelwood		Total
		No	Yes	
Households using Charcoal	Yes	9 15.80%	48 84.20%	57 100%
	No	4 5.80%	65 94.20%	69 100%
Total		13 10.30%	113 89.70%	126 100%
Fisher's Exact Test ^a				
Exact Sig. (1-sided)				
0.062				

^a Computed only for a 2x2 table

The response to the question of charcoal procurement (i.e. whether households make their charcoal themselves or buy from the market) is quite low (62 respondents of the total 128 valid response). Therefore this will only be reported for acknowledgment purpose here. The majority of the respondents (48 families) have indicated that they buy the charcoal from the market whilst a few families (14 families) indicate that they make their charcoal themselves (from remnants of burnt fuelwood after cooking)²⁴. About 9 families who buy their charcoal do not use fuelwood for their cooking. It should be noted that all households that make their charcoal also use fuelwood.

g) Seasonal Variation of Fuelwood Use

The variation of fuelwood consumption among households in the various seasons is presented in table 8.1g.

Table 8.1g: Fuelwood Use and Seasonal Variation of Higher Fuelwood Use

		Seasonal Variation of higher fuelwood use			Total
		Rainy Season (July to September) ^a	Harmattan Season (December to January) ^a	Hot dry Season (March to June) ^a	
Households using fuelwood	No	0 .0%	1 1.4%	0 .0%	1 .9%
	Yes	29 26.1%	72 64.9%	9 8.1%	110 99.1%

^a Approximate months of the season

The table suggests that fuelwood use is higher in the harmattan season (cool dry season)

²⁴ Charcoal in the study area is use for cooking particularly among small family size (less than 6), mostly in conjunction with fuelwood and, or with other sources of fossil fuels. It is also use during the harmattan season for warming the houses (see more discussion in sections 8.3.1 & 8.3.2.1 respectively).

than other seasons (72 families of the total 110 respondents). In contrast, only a few families (9 families) attributed a higher use of fuelwood in the hot dry season. Also, 29 families reported a higher fuelwood use in the rainy season. Although there is no statistical tests computed for this relationship because the status of households using fuelwood is constant in this association (SPSS output), the variables from the table revealed that 99% of the families noticed a seasonal variation in their use of fuelwood.

h) Quantity of Fuelwood Use

Table 8.1h indicates that out of the 99 families that responded to the question, the number of households that use less than 100kg of fuelwood in a month is 7 families (about 7% of the respondents' total).

Table 8.1h: Quantity of Fuelwood Use and Fuelwood Use

		Fuelwood quantity use			Total
		< 100 Kg	100 -249 Kg	250 -450 Kg	
Households	Yes	7	52	40	99
using fuelwood		7.1%	52.5%	40.4%	100%

In contrast, about 53% (52 families) reported that they use between 100kg to 250kg of fuelwood in a month, whilst the highest quantity (250kg to 450kg) is used by about 40% (40 families) of the respondents' total. It is evident from the table that the higher proportion of the households (about 93% of the respondents) uses between 100kg to 450kg per month, depending on the family size. This is further discussed in section 8.3.1.

i) The Interaction of Fuelwood Use and the Use of Modern Cooking Fuel

Table 8.1i shows the relationship between the use of modern cooking fuel and fuelwood among households.

Table 8.1i: Households using Modern Cooking Fuels and Fuelwood Use

		Households using fuelwood		Total
		No	Yes	
Households	No	0	53	53
using modern		0 %	100%	100%
cooking fuels	Yes	12	59	71
		16.90%	83.10%	100%
Total		12	112	124
		9.70%	90.30%	100%
Fisher's Exact Test ^a		Phi Test		
Exact Sig. (1-sided)		Value		Approx. Sig
0.001		0.283		0.002

^a Computed only for a 2x2 table

The table suggests that the use of modern cooking fuel alongside fuelwood is common among households. Out of the 124 families that responded to the question, 71 families (57%) use modern cooking fuel, out of which 59 families use it as an additional cooking fuel option (i.e. they use it in conjunction with fuelwood), while 12 families solely depends on it for their cooking. In contrast, there are 53 families (43%) that do not use any additional modern cooking fuel type for their cooking. The phi test result (0.30) revealed that there is a medium value of association between households that use modern cooking fuel as an additional cooking fuel option with households that use fuelwood or not. This value is significant (Fisher's exact test result, $p = 0.001$).

Overall, the most frequently used modern cooking fuel among households in the study area is kerosene, followed by electricity. The use of gas alone as a cooking fuel option was not reported by any family, but instead, gas was also used in conjunction with other modern cooking fuels (5 families). In contrast the few families (12 families) that are not using fuelwood for their cooking reported that they use either, kerosene (3 families); electricity (1 family); or a combination of kerosene and electricity (4 families); and kerosene, electricity and gas (4 families).

In response to the question on whether the households face any difficulty in accessing modern cooking fuel or not (Appendix 1: question 19), out of the 112 families that answered the question, 109 families (97%) faced difficulties in accessing modern cooking fuel whilst the remaining 3 families (3%) responded in the opposite. These obstacles range from the unreliability in the supply of the modern cooking fuels to its high cost. In relation to fuelwood usage for cooking, out of the 109 families that faced difficulty in accessing modern cooking fuel, about 100 families (92%) use fuelwood for their cooking as against a few households (9 families) that do not use fuelwood. This revealed that the use of fuelwood is higher among households that face difficulties in accessing the modern cooking fuel.

j) Households Cooking Fuel Choice

The cross tabulation between Households cooking fuel choice (i.e. households that are willing to switch over to the use of modern cooking fuel) and fuelwood use is presented in table 8.1j. The table revealed that the majority of the households are willing to switch over to the use of modern cooking fuel (99 families compared to 27 families). Interestingly, 89% of the households that are using fuelwood are willing to switch over to

Table 8.1j: Households Cooking Fuel Choice and Fuelwood Use

		Households using fuelwood		
		No	Yes	Total
Willing to Switch to modern cooking fuel use	Yes	11	88	99
		11.10%	88.90%	100%
	No	2	25	27
		7.40%	92.60%	100%
Total		13	113	126
		10.30%	89.70%	100%
Fisher's Exact Test ^a				
Exact Sig. (1-sided)				
0.442				

^a Computed only for a 2x2 table

the use of modern cooking fuel types if they are readily available. In contrast, only a few families (2 families who use charcoal) who do not use fuelwood show no interest in switching over to the use of modern cooking energy. However, the relationship in the table is statistically insignificant (Fisher's exact test result, $p = 0.44$).

k) Environmental Awareness

Table 8.1k is the relationship of households' environmental awareness (i.e. perception of their surrounding vegetation change going as far back as the respondents can recall) and fuelwood use.

Table 8.1k: Environmental Awareness and Fuelwood Use

		Households using fuelwood		
		No	Yes	Total
Environmental awareness	Yes	10	103	113
		8.80%	91.20%	100%
	No	3	9	12
		25.00%	75.00%	100%
Total		13	112	125
		10.40%	89.60%	100%
Fisher's Exact Test ^a				
Exact Sig. (1-sided)				
0.111				

^a Computed only for a 2x2 table

From the table, there is a high environmental awareness among the households. Out of the 125 families that responded to the question, 113 families (93%) mentioned that they have noticed changes in the vegetation (decrease in recent times compared to previous years) compared to only 12 families (7%) who did not notice any significant changes in the vegetation in recent times. Interestingly, households that use fuelwood constitute the highest number of households with environmental awareness (103 families). However, the value of this relationship is statistically insignificant (Fisher's exact test result, $p =$

0.11). Therefore, the result suggests that the majority of the households have noticed the depletion of the vegetation around them in the recent times.

The outcome of the results in section 8.1 provides some interesting associations between the explanatory variables with the use of fuelwood among households in the study area. The next sections (8.2 - 8.2.4), highlights some further observations made as a result of the extension of some of the associations identified in section 8.1 using stratified cross tabulation (see chapter 7: 7.2.9.4 for more detail).

8.2. Fuelwood Use Among Households

The result of the stratified fuelwood use percentage (table 8.2a) represents the relationship between the dependent variable; households that are using fuelwood, and the explanatory variables; number of people in a household and job type of the HoH (see table 7.7 in chapter 7: 7.2.9.4).

Table 8.2a: Fuelwood Usage Among Households

Job Type	Number of people in HH	Households using fuelwood		
		No	Yes	Total
Civil Servant	> 6 People	0	55	55
		0%	100%	100%
	< 6 People	7	22	29
		24.1%	75.9%	100.0%
	Total	7	77	84
		8.3%	91.7%	100%
Farmer	> 6 People		13	13
			100%	100%
	< 6 People		11	11
			100%	100%
	Total		24	24
			100%	100%

The table (8.2a) revealed that there are 108 (84.4%) valid and 20 (15.6%) missing responses out of the 128 households that were interviewed. Out of the 108 valid responses, the use of fuelwood is higher among households with larger family size than the smaller family size (101 families compared to 7 families). In contrast, all farmers use fuelwood compared to about 92% of the civil servants. The 8% of the civil servants who do not use fuelwood all have smaller family size. It was also revealed that employed households with less than 6 people and earning at least a minimum wage are more likely

to be using fuelwood for their cooking than civil servants on a high wage or unemployed families.

A logistic regression analysis was performed (refer to chapter 7: 7.2.9.5) to assess the effects of the number of people in a household and employment status of the HoH on fuelwood use. The model contained two variables; number of people in a household and employment status of the HoH as predictors. The full model containing all the two predictor variables was statistically significant ($\chi^2 = 34.891$, $df = 2$, $p < .000$).

This indicates that the model was able to differentiate between households that are using fuelwood from households that are not. The model as whole explained between 24.4% (Cox & Snell R Square) and 50% (Nagelkerke's R Square) of the variance in the use of fuelwood among households, and the overall prediction classification success of the model was 92%. The logistic regression result summary is presented in table 8.2b.

Table 8.2b: Logistic Regression Analysis for Variables Predicting Households' Use of Fuelwood

Predictor Variables (at the final step) ^b	<i>B</i>	<i>S.E.B.</i>	<i>Wald</i>	<i>df</i>	<i>p</i>	<i>e^B</i>
Number of people in HH (< 6 People = 0, n=49; > 6 People = 1, n=76)	20.093	4452.624	.000	1	.996	5.323E8
Employment Status (Unemployed = 0, n=15 ; employed = 1, n=110)	2.244	.820	7.479	1	.006*	9.429

^b Variables entered: Number of people in Household at the first step followed by Employment Status.

*Significant = $P < .05$

From the table, the Wald criterion demonstrates that only employed households made a significant contribution to the model prediction ($p = .006$). In contrast, unemployed households and households with less than or more than 6 people were not significant predictors of fuelwood in the study area. Therefore the strongest predictor of fuelwood use is the employed households (recording an odds ratio (e^B) of 9.43). This indicates that employed households were over 9 times more likely to use fuelwood, controlling for all other factors in the model.

8.2.1. Environmental Awareness of Deforestation Among Households

The respondent's perceptions about deforestation or vegetation change awareness were explored using the following responses; fuelwood procurement strategy, access to

household's preferred fuelwood type and the Job type of the HoH as the explanatory variables. The stratified deforestation awareness percentages (table 8.2c) revealed that; there are 96 (75%) valid and 32 (25%) missing responses out of the 128 households interviewed.

Out of the 96 valid responses, 92 households in all the categories have indicated that they are aware of the changes in their surrounding areas vegetation cover (reducing over the years). Surprisingly, 4 families who are civil servants and always buy their fuelwood from the market indicated a lack of awareness of their surrounding area's vegetation. Interestingly, all households, who always buy their fuelwood and face difficulties in accessing their preferred fuelwood type (irrespective of their job types), are more likely to be aware of the vegetation reduction in the study area over the years.

Table 8.2c: Vegetation Change Awareness Among Households

Fuelwood Procurement	Access to preferred fuelwood type	Job Type	Environmental awareness		Total
			Yes	No	
Self Procurement	Yes	Farmer	2		2
			100%		100%
		Total	2		2
			100%		100%
Buying always	Yes	Civil Servant	38	4	42
			90.5%	9.5%	100%
		Farmer	6	0	6
			100%	0%	100%
		Total	44	4	48
			91.7%	8.3%	100%
	No	Civil Servant	31		31
			67.4%		67.4%
		Farmer	15		15
			32.6%		32.6%
		Total	46		46
			100%		100%

Overall, the results suggested that the majority of the households in the study area irrespective of their job types and accessibility of their preferred fuelwood type are aware of the reduction of their surrounding's vegetation in recent years. However, farmers and households that are using family labour to fetch their fuelwood from the forest appeared to be more concerned about the changes in the vegetation of the study area.

A logistic regression analysis was performed to investigate the influence of fuelwood procurement strategy, access to household's preferred fuelwood type and the employment status of the HoH on the likelihood of the households being aware of

deforestation in their environment. The model contained three variables; employment status of the HoH, fuelwood procurement strategy and access to household's preferred fuelwood type as the predictors. The full model containing all the three predictor variables was statistically significant ($\chi^2 = 17.879$, $df = 2$, $p < .000$).

This indicates that the model was able to differentiate between households that are aware of the changes to the vegetation of the study area and those households that are unaware of the changes to the vegetation. The model as whole explained between 15.1% (Cox & Snell R Square) and 34.8% (Nagelkerke's R Square) of the variance in the awareness of the changes to the vegetation among households, and the overall prediction classification success of the model was 94.5%. A summary of the logistic regression results is presented in table 8.2d below.

Table 8.2d: Logistic Regression Analysis for Variables Predicting Individual's Awareness of Their Surrounding Deforestation Problems

Variables (at the final step) ^b	<i>B</i>	<i>S.E.</i>	<i>Wald</i>	<i>df</i>	<i>p</i>	<i>e^B</i>
Employment Status (Unemployed =0, n=8 ; employed= 1, n=101)	2.356	.974	5.845	1	.016*	10.547
Fuelwood Procurement (Buying always =0, n=102 ; Self Procurement = 1, n=7)	-2.685	1.001	7.198	1	.007*	.068

^b Variables entered: Employment Status at the first step followed by Fuelwood Procurement. Control is access to preferred fuelwood type. *Significant= $P < .05$

From the table, the Wald criterion demonstrated that employed households and households that are procuring their fuelwood using family labour made a significant contribution to the model prediction ($p = .016$ and 0.007). In contrast, unemployed households and households that are buying their fuelwood from the market, and households with or without access to their preferred fuelwood type are not significant predictors of the model. This shows that the strongest predictors of vegetation change awareness among households in the study area are employed households and households that are procuring their fuelwood using family labour, each recording odds ratios of 10.547 and 0.068 respectively. This indicates that employed households were over 10 times more likely to be aware of the vegetation change among households in the study area, controlling for access to households and preferred fuelwood type factor in the model.

8.2.2. Perception of Using Other Modern Cooking Fuel Among Households

The attitude of the respondents towards using modern cooking fuel was explored. Their responses on their willingness to switch to the use of other alternative energy to fuelwood (WiOCT) were considered as the dependent variable, whilst the number of people in household; employment status of the head of the HoH and households that are facing obstacles to use alternative cooking fuel types were used as the explanatory variables. The result is presented in table 8.2e.

The table indicates that there are 112 (87.5 %) valid and 16 (12.5 %) missing responses out of the 128 households interviewed. The results revealed that more households (58 households compared to 15 households) within the category of more than 6 people in the family (irrespective of their employment status) are willing to switch over to the use of

Table 8.2e: Households Willingness to Switch to the Use of Modern Cooking Fuel

Number of people in Household	Employment Status	Obstacles to using other cooking fuel types	Households cooking fuel Choice (willing to change or not)		Total	
			Yes	No		
> 6 People	Employed	Yes	52	14	66	
			78.8%	21.2%	100%	
		No	1	0	1	
			100%	0%	100%	
	Unemployed	Yes	5	1	6	
			83.3%	16.7%	100%	
		Total	58	15	73	
			79.5%	20.5%	100%	
	< 6 People	Employed	Yes	20	9	29
				69%	31%	100%
No			2	0	2	
			100%	0%	100%	
Unemployed		Yes	7	1	8	
			87.5%	12.5%	100%	
		No	2	0	2	
			100%	0%	100%	
Total		29	10	39		
		74.4%	25.6%	100%		

modern cooking fuel. Unemployed households that are facing difficulties in using other cooking fuel types also show their interest to switch over to the use of the modern cooking fuel. In contrast, a considerable number of households within the large family size indicate that they are not willing to switch over to the use of modern cooking fuel

despite being employed. However, all of them (14 households of employed large family size) have indicated that they are facing difficulties in using modern cooking fuel types. Overall, the majority of the households (about 78%) irrespective of their family size, employment status and difficulties in using other cooking fuel types are willing to switch over to the use of modern cooking fuel if they are readily available at an affordable price.

A logistic regression analysis was performed to assess the effect of the likelihood that the households would switch to the use of modern cooking fuel. The model contained four variables; Number of people in household, employment status of the HoH, households that are facing obstacles to use alternative cooking fuel types and Households using additional cooking fuel type as predictors. The full model containing all the four predictor variables was statistically insignificant ($\chi^2 = 3.456$, $p = .485$ with $df = 4$).

This indicates that the model was unable to differentiate between households that are willing to switch to the use of modern cooking fuel from households that are not. Table 8.2f is a summary of the logistic regression results.

Table 8.2f: Logistic Regression Analysis for Variables Predicting Households' Choice to Switch Over to the Use of Alternative Cooking Fuel

Predictor Variables (at the final step) ^b	<i>B</i>	<i>S.E.</i>	<i>Wald</i>	<i>df</i>	<i>p</i>	<i>e^B</i>
Number of people in HH (< 6 People =0 , n=39; > 6 People =1, n=72)	.490	.496	.974	1	.324	1.632
Employment Status (Unemployed =0, n=14; employed = 1, n=97)	-.783	.812	.930	1	.335	.457
Obstacles to using other cooking fuel (no=0, n= 3; yes= 1, n= 108)	.295	.477	.384	1	.536	1.344
Households using additional cooking fuel type (no=0, n=48; yes= 1, n=63)	-20.120	23104.029	.000	1	.999	.000

^b Variables entered: Number of people in Household followed by Employment Status, Obstacles to using other cooking fuel and Households using additional cooking fuel type. *Significant= $P < .05$.

From the table, none of the four predictor variables is significant at $p < .5$. Therefore, the model was not good enough to differentiate household's willingness to switch over to the use of modern cooking fuel in the study area. This is likely due to the low expectations among households on the reliability of fossil fuel supply (see more discussion in section 8.3.2.2 & chapter 10).

8.3. Discussion of Results

8.3.1. Fuelwood Consumption in the Study Area

The preceding sections of this chapter highlighted how fuelwood demand continued to be part of the complex issues surrounding deforestation in the study area. It was obvious from the results that the demand for fuelwood is higher among the households where the majority of them are faced with the only option of using fuelwood at the expense of the limited vegetation cover despite their environmental awareness of its scarcity (see table 8.1k & section 8.2.1).

Fuelwood still remains an important cooking fuel in Nigeria, which in terms of consumption compared to other energy sources (see section 8.1(i) above), is quite high (Bugaje, 2006 & NPC, 2010). The fuelwood situation (see chapter 2: 2.3.2) in Nigeria has been monitored and reported in the past with virtually all the researchers affirming the significance of fuelwood in the household energy demand particularly in the northern part of the country (Morgan, 1978; Bdiya, 1987; Cline-cole et al., 1987 & 1988; Nichol, 1989 & 1990, Mortimore, 1990; Cline-cole et al., 1990 a & b; Cline-Cole, 1998; Odihi, 2003 & Maconachie et al., 2009).

The consumption pattern of fuelwood in the study area was similar to those reported by previous researchers in Northern Nigeria. For example, table 8.1g above revealed the quantity of fuelwood used among households which show that the majority of the households use large quantities of fuelwood. This coincided with the findings of Alabe (1996) and Odihi (2003) where they both ascertained the high consumption of fuelwood in Yobe State. The finding here, which also shows that households with many people are more likely to be using fuelwood in a substantial quantity was earlier reported by Odihi (2003) and Alabe (1996) in Borno and Yobe state; Kutuyi and Kirubi (2003) in Kenya and San et al. (2012) in Kampong Chnang Province of Cambodia. Other related studies of household fuelwood consumption per head in the northern part of Nigeria were reported by Cline-Cole et al. (1987 & 1988), in a survey they conducted in the early 1980s. Their study put the annual consumption rate of fuelwood per person at 360 kg and a monthly household consumption at 332kg in Kano. Similarly, Alabe (1996) in his survey of about 1,500 households in Yobe state and 2,000 households in Borno state between 1993 and 1994 reported that urban households in Yobe (like Potiskum) consume about 328 Kg of fuelwood annually (per head) and 333 Kg in Borno, while in the rural areas, households

(like Nangere in the study area) annually consume about 257 kg and 282.5 Kg of fuelwood per head respectively in Yobe and Borno states. However, this research findings' (refer to section 8.1h above) partially contradict Alabe's (1996) findings in terms of proportion of local area consumption (urban-rural consumption pattern) where it was found in the study area that the annual consumption of fuelwood per head in Potiskum area was approximately 330 Kg (close to Alabe's findings) while that of Nangere is around 470 kg (contradicts Alabe's findings -see figure 8.1 below, & chapter 7: 7.2.5.1 & 7.2.5.2 for discussion of the data).

The two contrasting findings in terms of quantity of fuelwood consumption (especially in the rural areas) could be the time difference of about 15 years between the times of data collection for the two studies. Also, given that some households in Nangere now supplement their supply of fuelwood from the trees they own in their farmlands (see more discussion in section 8.3.3.2) due to the significant reduction in the supply of

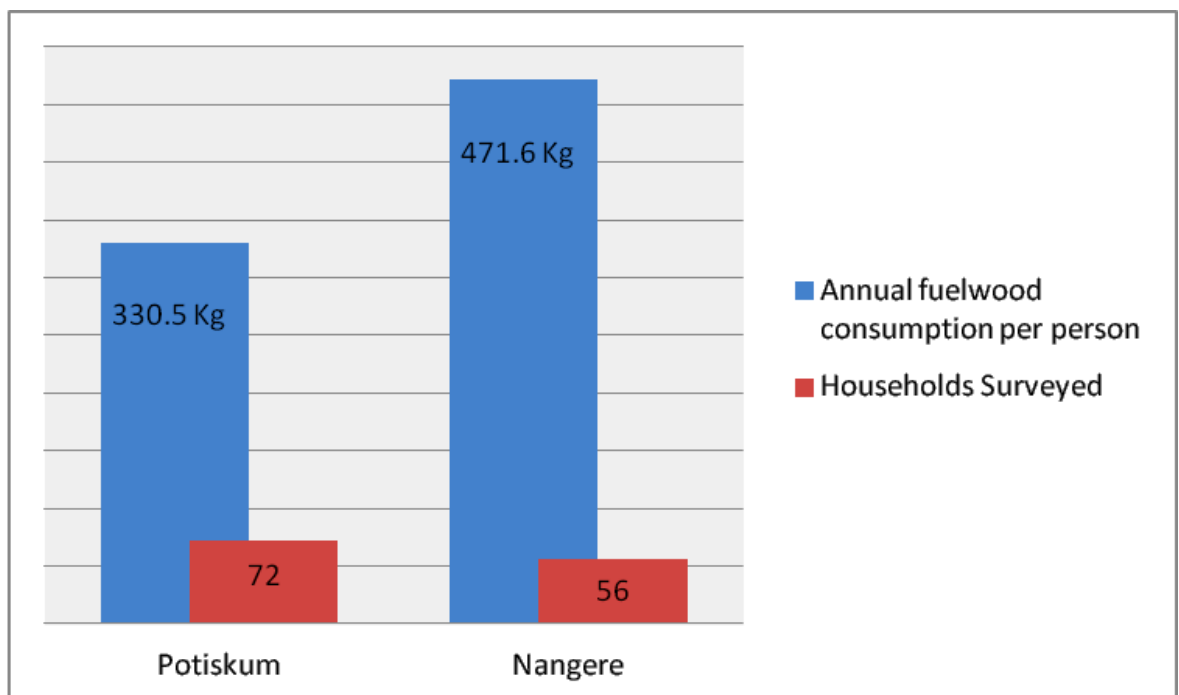


Figure 8.1: Annual Fuelwood Consumption per Head

Data source: Researcher's field survey.

modern energy sources in the northern part of Nigeria since then (Maconachie et al., 2009), the quantity reported in this study could be the obvious reflection of the current reality in the study area. This is further discussed in the subsequent sections.

The consumption figure obtained in this study was achieved using a crude estimate of the total quantity of fuelwood consumption of households divided by the the total number of

people in the households (see questions 1 & 15 in appendix 1) and multiplying the result by 52 (approximate weeks in a year) to obtain the annual figure per head. However, it is worth noting that the figure excludes charcoal use which was observed to be solely used as a source of cooking fuel by only 9 households and another 48 households that used it in conjunction with fuelwood. Also, the households that use charcoal in their cooking have confirmed that they buy the charcoal from the market; and upon consultations with the vendors, they confirmed that they also buy it from the southern part of Nigeria by taking the advantage of the “cheap” transport network system of the frequent long trucks (locally referred to as trailer) movement from the north to the southern part of Nigeria. The “trailer” business is very well-known in Potiskum because of its long establishment in the town which make it an important measure of economic status among the local people of Potiskum.

8.3.1.1. Fuelwood Procurement and Family Expenditure

The fuelwood procurement strategy has for long remained a contentious point of discussion among researchers (see chapter 2: 2.3.4). This study also investigated the procurement strategy of households in sourcing their fuelwood, whose patterns were presented in tables 8.1e. The result shows that only a few households used family labour in procuring their fuelwood. This was earlier reported by Cline-Cole et al. (1987) in Kano where the majority of the households buy their fuelwood from the market rather than relying on family labour. This result revealed two suggestions in the study area; 1) either the study area’s households are already facing the shortages of wood supply, which is why they have to rely on the commercial vendors who fetch it from far distant places at an additional cost; or; 2) there was a shift in the earlier paradigm held among most earlier researchers regarding fuelwood acquisition process that emphasised the use of predominantly family labour (more especially women and children) in supplying household needs. This study only fully agrees with the first suggestion, because more than 90% of the households buy their fuelwood from the market irrespective of their economic status. On the other hand, the second suggestion cannot be fully supported in this study given that questions 6 and 9 (appendix 1) that asked the question did not specify whether the respondents should mention the family members who help with the chores. However, based on the responses obtained (on questions 6 & 9) from the few households that solely or partially relied on family labour for their supply (table 8.1e above), none of the respondents mentioned about relying on his wife or children in the

wood supply from farmlands or forest. This could be due to the cultural belief of most households in the study area (predominantly Muslims) which placed the task of food and related items supply (sourcing of household needs) fully on the husband.

Although responses from two households that buy their fuelwood (specifically in Nangere town) confirmed that *“sometimes they prefer to buy from young children (Almajiri) because it is easy to negotiate a price with them and get it cheaper than from the vendors”*. This latter attestation by the two households of using younger children who lacked experience of the business, was part of the complex issues surrounding the northern part of the country (see box 8.1 for a brief description of *Almajiri*). It is thus, not surprising at all when these households mentioned their relevance in the procurement process.

Box 8.1: A Simple Description of *Almajiri* in Northern Nigeria

The “*Almajiri*”- Hausa name for the children referred to by the two households are the kind of young children sent by their parents from a distant far place to other unfamiliar areas in the name of pursuing an “Islamic education”. These groups of children (sometimes numbering more than 40) are placed under the care of their teacher (*mallam*) without any support from the parents as regards their feeding or welfare; as a result, most of them were taking advantage of by the local households as a means of cheap labour. Nonetheless, what was known regarding the “*Almajiri*” system in the Northern part of the country remained closely similar to the United Nation analogy of child poverty and negligence. This is because as young children, they must beg to survive, which is why across the northern Nigeria, an afternoon break in the *Almajiri* classes sends the children flooding into the streets with small bowls to search for any scraps (Purefoy, 2010). This can further be illustrated using the BBC World service news that reported a 14-year-old boy who had lived as *Almajiri* for 10 years saying that *“it is compulsory for us to go out and beg every day. If we stayed at the mallam's house he's not going to provide us with food - we have no option but to go out and beg”* (BBC Africa, 2008).

The result of this study also found that only about 19% of the households interviewed spend less than 1,800 Naira (about £7.20) (i.e. 10% of the national minimum wage of 18,000 Naira) on the purchase of fuelwood, while about 81% spend more than 10% of the national minimum wage on the purchase of fuelwood monthly.

Figure 8.2 below, shows the spending pattern on fuelwood in relation to household income.

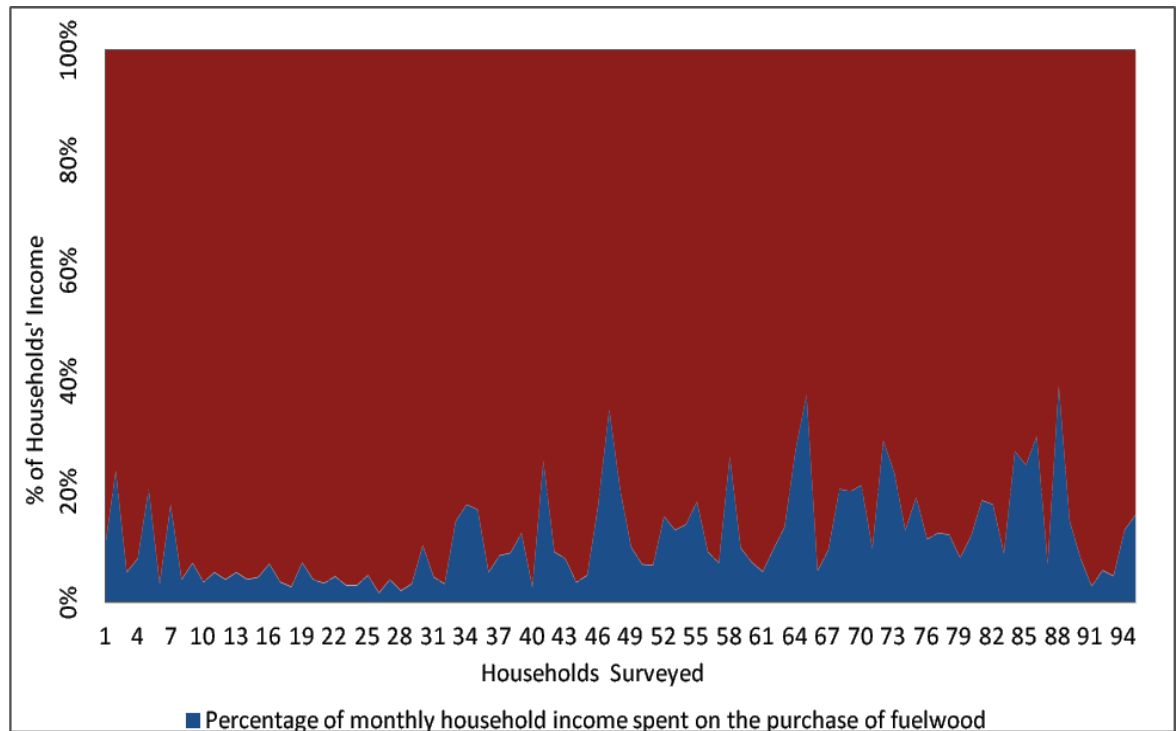


Figure 8.2: Proportion of Monthly Spending on Fuelwood Purchase Compared to Household Monthly Income

From figure 8.2, it is revealed that the majority of the households spend between 15% to 20% of their monthly earnings on the purchase of fuelwood, while a few households spend up to 35% of their monthly income on the purchase of fuelwood. This is observed to oppose some of the earlier views of many researchers of fuelwood who assumed that fuelwood is “freely” available. Even though it is available as they have claimed (since the households can buy it from the vendors), a deduction of more than 10% of the total household’s earnings that goes to fuelwood procurement alone is high enough to qualify fuelwood as a scarce commodity in the study area. Mortimore (1990) has earlier cautioned that the expenditure on the procurement of fuelwood in Northern Nigeria will continue to rise in the long run unless there is a change in the supply of the modern cooking fuel types to the region. The present household expenditure on fuelwood procurement also confirmed Mortimore’s earlier position, given that no significant changes have occurred in terms of the supply of the modern fossil fuels in the region (see more discussion in chapter 6 & section 8.3.2.2 below).

8.3.1.2. Variation in the Use and Price of Fuelwood

The consumption and procurement of fuelwood varied in relation to seasonal changes in the study area (refer to 8.1d above). The highest increase of fuelwood prices during the rainy season was as a result of the difficulties surrounding the procurement during this

season. Some of these difficulties (according to the households; the vendors (see full discussion in chapter 9) and my personal experience during field trip) relates to the inaccessibility of the forest during the rainy season due to the nature of the roads (earth roads) - (see plate 8.1, photos from field trip below).

According to the vendors, stockpiling of fuelwood during the dry season (through hoarding) is a strategy for easing the problem of forest inaccessibility by road during the rainy season, which is why the price rises during this period (see full discussion chapter 9: 9.2.8 & 9.3.4). Another problem also elaborated by 10 households was that during the rainy season, the majority of the labourers engaged in the procurement of fuelwood from the forest change to temporary farm labouring which also reduce the supply. This was also confirmed by the vendors (see chapter 9:9.3.4).

In contrast to the seasonal variation in fuelwood pricing, about 66% of the households reported that they use more fuelwood during the harmattan season than the rainy season (see table 8.1g above). This was as a result of reasons other than cooking (heating and water boiling). For example, the majority of the households confirmed that charcoal, made from the remnants of the wood they used during cooking was also used in warming their houses during the harmattan season. Others (a few households from Nangere town) indicated that during late evening conversations (outside their homes) with friends, they also use wood to warm themselves in the harmattan season. Similar findings were previously reported by Cline-Cole et al. (1988) and Alabe (1996) in the northern part of Nigeria. In addition, Alabe (1996) equally reported the role of festive periods in the amount of fuelwood used. This was also reported by a few households when they were asked to expand on some of their responses. They revealed that festivals (i.e. wedding, naming ceremonies, fasting periods and the two Eid periods²⁵); and occasions such as a new birth (where the tradition in the area is for the new mother to take hot bath twice a day and also to continue using warm water (as drink) for a period of between thirty to forty days) equally plays an important role in the way households use more fuelwood than the normal periods. This was also among the reasons why the actual per head

²⁵ Muslims around the world celebrate two Eids festivals in a year. The first Eid celebration of the year is known as Eid Al-Fitr (end of Ramadan festival). It marks the end of the month of Ramadan, which is the month in which Muslims fast every day from sunrise to sunset for thirty days. The second Eid celebration of the year is called Eid Al-Adha (the Festival of Sacrifice). It commemorates the completion of the muslim Hajj pilgrimage. Although only pilgrims in Mecca participate in the Hajj fully, Muslims around the world join them in celebrating Eid Al-Adha.



Plate 8.1: Nature of the Roads Leading to One of the Forests in the Rainy Season

Source: Author's field trip, 28th July 2010.

consumption of fuelwood in the study relied on an estimate. For example, one of the respondents narrated his experience after a child birth as follows: *“ I usually use 1,000 Naira (about £4) worth of fuelwood per month (in conjunction with modern fuel) given that we are only 4 in the house, however, after we had our recent baby I had to use a small truck full of fuelwood in the month and that cost me over 3,000 Naira (about £12)”*. However, a few households among the 29% that use more fuelwood during the rainy season explained that they used more fuelwood in the rainy season due to farming activities, when more food is required by the farmers working in the fields.

8.3.2. Reasons for the High Consumption of Fuelwood in the Study Area

The over dependence on the use of fuelwood in the study area, like most places in Northern Nigeria, was the product of numerous issues concerning fossil fuel supply and affordability. Below is the discussion of some of the critical reasons for the high consumption of fuelwood in the study area.

8.3.2.1. Additional Cooking Fuel Types Use

Maconachie et al. (2009) in their recent study in Kano highlighted the continuing shift of middle-income families away from the use of fossil fuels (due to irregularity in their supply) to traditional fuelwood. This was also highlighted earlier in this study (see sections 8.1c, d & 8.2.0), where the majority of the households were reported to be relying on fuelwood regardless of their economic or social status. However, increasing family size was seen as an important indicator of fuelwood use than the economic status of the family in this study. This was reported in tables 8.1a and 8.2a. In contrast, those households with less than 6 people have choices they can make (see further discussion in section 8.3.2.3 below).

Even though the use of charcoal for cooking was reported by only a few households who cook for less than 6 people, the majority have indicated that they use it in conjunction with fuelwood. Alabe (1996) reported a similar findings in the study area about two decades ago, where he noted that charcoal was extensively used among households during the harmattan season for heating, while some few households (with small families) also use it to cook. Although the use of charcoal for cooking among the majority of its users in the study area was for complementary purpose, it is also worth noting that charcoal use in the area is now gaining popularity among the small households (see

section 8.1f). This is likely due to the size of the charcoal cooking stoves used among households in the study area as highlighted by a few households that uses it (normally small in size and can only be use with small cooking pots).

Similarly, a few households in this study also reported that they use animal dung locally called “*Kandilo*” and the stalks from their crop residues during the dry season to complement fuelwood supply. This was reported mainly when the respondents in Nangere town were asked to further explain on question 6 (appendix 1). Given that the use of *kandilo* was only mentioned by a few households in Nangere town alone, it can be argued that its use is more confined to the rural areas.

Apart from using fuelwood for cooking, most households also use modern cooking fuels such as kerosene, gas and electricity in conjunction with fuelwood. The majority of the households indicated that they use kerosene for starting the fire (when cooking with fuelwood) especially in the rainy seasons. Other items such as polythene bags, scraps of plastic pieces and papers are also used for starting the fire.

The use of electricity was next to kerosene in the study area in terms of importance followed by gas. However, the provision of these fuels in Nigeria is insufficient (see chapter 2: 2.5.1-2.5.2 & the discussions of chapters 6), which is part of the reasons why none of the fossil fuels was used in isolation without complementing it with fuelwood in the study area (see figure 8.3 below).

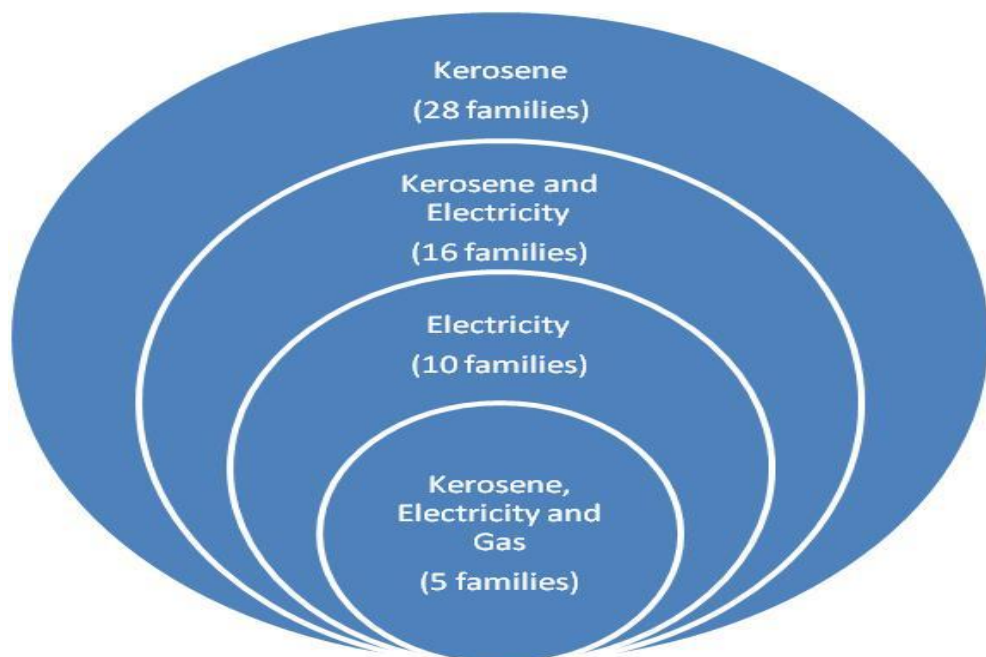


Figure 8.3: Distribution of Modern Cooking Fuel Used Alongside Fuelwood

8.3.2. 2. Obstacles to using other types of cooking fuel

As observed earlier by Cline-cole et al. (1987); Mortimore (1990); Alabe (1996); Casse et al. (2004); Maconachie et al. (2009) and Arabatzis et al. (2012), this study also confirmed that the majority of households relied on fuelwood for two main reasons, 1) the economic situation in the country, and; 2) unreliability in the supply of modern cooking fuels.

The economic situation lies with the fact that the majority of households are low and minimum wage earners (see section 8.1d), which places them in a vulnerable economic situation (refer to chapter 6: 6.5.3.1 -6.5.3.2), given that the prices of modern cooking fuels are always on the rise²⁶, with no substantial improvement in the economic situation of the households. The economic situation of households together with the irregular supply of fossil fuels in the northern part of Nigeria due to many factors (see chapter 6: 6.5.2), were among the reasons for the high dependence on fuelwood in the study area (Cline-cole et al., 1987 & 1988; Nichol, 1990; Hyman, 1994; Alabe, 1996; Odihi, 2003 & Maconachie et al., 2009). The unreliability in the supply of fossil fuel to the study area is similar to that of Kano and many other northern parts of Nigeria. The issue of petroleum products supply in the northern part of Nigeria can be summarised with the quotation from Maconachie et al. (2009, p. 1096) based on the response they received from the spokesperson of the Kano Independent Marketers of Petroleum Product in 2008, where he mentioned that - *“out of the estimated 110 official trucks that were meant to transport about 3.632 million litres of Household Kerosene (HHK) to Kano daily, only about 2-3 trucks (around 66,000 to 99,000 litres) reach Kano daily.”*

There could be an exaggeration in the figure of HHK presented by the marketers' spokesperson, as it is only reasonable if he meant the supply of both HHK and Premium Motor Spirit (PMS) to Kano depot (Kano depot serves Kano, Jigawa, Katsina and parts of

²⁶ For example there was an increase in the official pump price of kerosene from 17 Naira (£ 0.068 Pence) in 2001 to 50 Naira (£ 0.20 Pence) per litre in 2012, while the price of bottle gas rose from 1,000 Naira (£ 4) in 2001 to 3,500 Naira (£14) per 12.5kg in 2012 (the price was increased 6 times within these periods; see the history of fossil fuel price increase in Nigeria from 1973 to 2012 in chapter 2: 2.5.1.3 and some discussion in chapter 6: 6.5.1). It should however be noted that the products are hard to find at the official price and people resort to buying from the black market. This can be illustrated by the following report in *Daily Trust Newspaper* of 26th Jan 2011: *“Kerosene, a major energy source for households especially in the urban centres, is difficult to get at many filling stations... People wanting to buy the product have to do so at the black markets. The scarcity has caused a spike in the pump price of the commodity, from 50 Naira per litre, to between 120 Naira (£ 0.48 Pence) and 150 Naira (£ 0.60 Pence) per litre at filling stations and is sold for 200 Naira (£ 0.80 Pence) per litre at black markets”* (Muhammad, 2011).

Yobe and Bauchi states- refer to chapter 2: 2.5.1 for more detail). Since in a different statement made available to Daily Trust Newspaper in Kano on 1st September, 2003, the Kano state secretary-general of the Independent Petroleum Marketers Association of Nigeria (IPMAN), Alhaji Sani Yau Babura noted that the total requirement of Kano, Jigawa, Katsina and parts of Yobe and Bauchi states catered for by the Kano NNPC depot, was 60 trucks of PMS per day (Kazaure, 2003), and the daily allocation of PMS to the various states is higher than HHK (NNPC, 2010). Nevertheless, the Kano state IPMAN secretary-general also lamented that these states are being under supplied with petroleum products by the NNPC (by about 80 per cent). This could be the reason why the Kano state government in 2012 plans to seal an agreement with Niger Republic to import petroleum products from Niger for its domestic use (Kano, 2012).

Although there were no official records confirming these amounts in the literature, the story is nevertheless not far from the reality on the ground, because the majority of the respondents in this study have confirmed that some of the issues discouraging them from using modern fuels include high cost as well as its unreliability compared to fuelwood.

8.3.2.3. The willingness to switch Over to Modern Fuel Use

The results of sections 8.1j and 8.2.2 revealed the considerable interest shown by households in switching from traditional fuelwood to modern cooking fuel if the supply was constant and prices were affordable. However, households with a family size of more than 6 people are less likely to be interested in switching over to modern cooking fuel than households with less than 6 people. Therefore, apart from the high price and shortage of modern cooking fuel, this study also discovered that cultural or traditional practices and family size have some influence on the choice of cooking fuel.

The cultural practices presented by most of the households was either in the dish (diet) type or cultural attachment to their traditional ways of cooking, which were also reported earlier by Odihi (2003); Kituyi and Kirubi (2003) and Maconachie et al. (2009). Both practices were cultural principles that are very difficult to eradicate from the minds of these households. For example, the common food in the study area locally called “*Tuwo*” (made from grounded cereal crops produced in the northern region e.g. maize, millet, guinea corn, rice, wheat e.t.c) is considered by the residents to be properly cooked using fuelwood. According to the households, the preparation of “*Tuwo*” which require much

heating is easier using fuelwood than kerosene or gas especially if one is cooking for a large family (see table 8.1a). Similar observations were also reported by Cline-cole et. al. (1987); Alabe (1996) and Maconachie et al. (2009). Equally reported by these researchers that conformed to the findings of this study was the size of the family which influence the decision to switching over to modern cooking fuel types. Larger households confirmed that it is very difficult to use kerosene or gas even it is available to cook for many people due to their high price compared to a similar unit price quantity of fuelwood.

8.3.3. How Easily Available is the Type of Fuelwood Preferred in the Study Area?

The study area is already facing difficulties in accessing fossil fuel as discussed in sections 8.3.2.2 and 8.3.2.3. Therefore, this section will discuss the situation in relation to fuelwood accessibility.

8.3.3.1. Types of Wood Used as Fuelwood in the Study Area.

The preferred type of wood species used for fuelwood are presented in table 8.3 below.

Table 8.3: List of Preferred Fuelwood Types

Hausa Name (Local Name)	Botanical Name	English Name
Ádúúwàà	<i>Balanites aegyptiaca</i>	Desert date
Báushè	<i>Terminalia spp.</i>	-
Céédííyáá	<i>Ficus thonningii</i>	-
Dóóràwà	<i>Parkia biglobosa</i>	Locust tree
Gààwóó	<i>Faidherbia albida</i>	Winter thorn
Gàmà fádà	<i>Cassia arereh; C. Sieberana</i>	-
Matsagi (Jalahe)	<i>Bauhinia rufescens</i>	-
Kányà	<i>Diospyros mespiliformis</i>	West African Ebony
Kántákàráá (Kattakara)	<i>Combretum glutinosum;</i> <i>C. Lamprocarpum</i>	-
Kárgóó	<i>Piliostigma reticulatum; P. thonningii</i>	-
Kíryà	<i>Prosopis africana</i>	False locust
Margosa, Dóógón yááròò (Maina)	<i>Azadirachta indica</i>	Neem Tree
Mádààcíí	<i>Khaya senegalensis</i>	Mahogany
Máájè	<i>Daniellia oliveri</i>	Copaiba balsam
Márkéé	<i>Anogeissus leiocarpus</i>	Chewstick tree
Sààbàràà	<i>Guiera senegalensis</i>	-
Táuráá	<i>Detarium microcarpum</i>	-
Tsáámííyáá	<i>Tamarindus indica</i>	Tamarind
Wúyàn dámóó	<i>Combretum molle; C. Glutinosum</i>	-

Source: Field investigation; Names confirmed from Blench (2007).

Although the majority of the households have multiple choices of their preferred fuelwood type, the most preferred species of trees are: *Prosopis Africana*, *Anogeissus leiocarpus*, *Guiera senegalensis*, *Piliostigma reticulate*, *Combretum molle* and *Bauhinia rufescens* (Jalahe). These species are preferred because of their high quality in terms of heat output, good combustion and their potential to produce less smoke even when they are wet (during rainy season) (Alabe, 1996). Plate 8.2 shows photographs of *Piliostigma reticulate* and *Combretum molle* respectively.



Plate 8.2: Example of Trees Use for Fuelwood in the Study Area

(Top: *Piliostigma reticulate*, and; Bottom: *Combretum molle*).

Source: Author's field trip, 12th October, 2010.

However, these important tree species identified by the households are becoming scarce in the study area, because even among the households that do not notice their scarcity (see section 8.1e), the majority have confirmed that fuelwood is always available but the prices are rising. This evidence provided by the households also introduced part of the complex pattern of fuelwood collection by the vendors who have to cross administrative borders to procure the wood (see full discussion of fuelwood vendors' activities in

chapter 9). This was equally reported by Cline-cole et al. (1987) and Maconachie et al. (2009) in Kano, where some of the procurement distance was far beyond the administrative boundary of Kano. However, as confirmed by one of the vendors, *“the increasing procurement distance in sourcing these particular types of wood species is an indication that they are becoming scarce when one compared the situation in the past few decades, where they can be found within a short distance”*.

8.3.3.2. Distance to Procurement Centres

This study has categorised fuelwood procurement distance into households that obtained their fuelwood from the vendors in the market and households that obtained their wood from their farmland or forest (section 8.1e). It was revealed that the majority of the households in the study area obtained their fuelwood from the market. This contradicts some of the findings of Jelwic and Van Vegtan (1981); Leach (1987); Ghilardi et al. (2009) and Palmer and Macgregor (2009), who reported fuelwood collection among households using family labour as part of the causes of deforestation in their respective study areas. Even though, the finding in this study concurred with some of these researchers in relation to the high demand of fuelwood among households in their respective study areas, the findings here contrary to their findings noted the active role of commercial fuelwood collection in the study area, which is assumed to be a major cause of deforestation. The commercialisation of fuelwood collection was also reported by Ali and Benjaminsen (2004) and Bensel (2008) in their respective studies as a major cause of deforestation.

A new approach to the procurement of fuelwood in the study area that has not been reported previously in the northern part of Nigeria among households is the increasing awareness of the shortage of fuelwood and the need for planting of more trees (especially neem trees – refer to table 8.3) in the farmlands in order to supplement the supply from the market. This is a common practice amongst some households in Nangere town, who believed that tree ownership is an important occasional strategy in reducing the cost of fuelwood supplied by the vendors. The neem tree, referred to as “Maina” by the local people, is a tree in the mahogany family with broad dark brown stem and widely spread branches, *“it can easily be established without irrigation in Northern Nigeria and grows rapidly, providing fuel and timber in just about 5-7 years..... and unlike most other native trees and shrubs in Africa, the neem trees are seldom damaged by wandering*

animals” (Radwanski, 1969, p. 507). The tree was introduced to Northern Nigeria through the government afforestation programme in order to prevent desertification and to provide shades in the towns (Odihi, 2003). However, given its high potential of growing very fast in the arid areas, the tree is now gaining much popularity among households who mentioned it as being an important fuelwood source. It is worth mentioning that the neem tree also has other economic benefits among households in Nigeria through its numerous potential by-products (medicines, factory chemicals, oil etc) (refer to Radwanski, 1969 & Salako et al., 2008, for more details on the economic potential of the neem tree).

8.3.3.3. Environmental Awareness

The response from the survey (table 8.1k & section 8.2.1) revealed that only a few families indicated their ignorance of the changes to the study area’s vegetation in recent times. In contrast, about 92% of the households in the study area maintained that the vegetation of the study area has reduced in recent times compared to the last two to three decades. This higher awareness among the households could be attributed to the economic reality facing most families in the study area, who recently have to pay more to the vendors that travel long distances to procure the wood. Nevertheless, a few observers among them (respondents) have a different way of saying it, one of them has this to say; *“people are increasing and the demand for fuelwood is ever increasing because there was no substitute at an affordable price....; in the past (about 30 years ago) one can hardly wander freely in the forest because of the density of the vegetation cover, but now.... (He nodded his head several times and smiles... before he continues), one can ride a horse freely from all directions in our nearby forest with his eyes close... If he so wishes without any fear of running into a tree”*. This statement although somehow exaggerated, was a revelation on how some of the people feel about the changes of their surrounding vegetations in the area. This higher awareness about deforestation among households was equally reported earlier by Alabe (1996) and Odihi (2003) in some parts of Borno and Yobe states; and more recently by Maconachie et al. (2009) in Kano.

Although further discussion would lie outside the scope of this study, it is worth mentioning that there is a widely held view among the general public and environmentalist in Nigeria that desertification is responsible for changing the land cover of most areas of the arid northern part of Nigeria. More specifically, it has been claimed

that desert is moving southwards at the rate of 10 Km per annum (Odiogor, 2010). Surprisingly, most of the researchers reporting these figures do not provide any scientific evidence to confirm them. For example, Alabe (1996, p. 44) reported that “ *fuelwood seems the major source of fuel in Yobe and Borno states, which is among the reasons for the loss of an estimated 4km² of useful land every year...*”. This kind of view was held by researchers without any rigorous scientific studies to validate it, despite the fact that recent studies of Sahel changes are saying the opposite i.e the desert boundary in Northern Nigeria is moving northwards (Ayamba & Tucker, 2005 & Olsson et. al., 2005) (refer to chapter 2: 2.6 & chapter 4: 4.2.2 for more detail). However, it can be argued that the long-standing myth of progressive desertification is politically motivated and used by the government in order to attract foreign financial assistance. According to Professor Sani Abubakar Mashi of Umaru Musa Yar’adua University, Katsina state Nigeria, if the belief was actually true, a continual reduction of about 10Km annually would be large enough to have destroyed the vegetation of the Northern Nigerian region by now (personal communication in June, 2010). But instead, as reported in chapter 4 and confirmed in chapter 9, the fuelwood consumed in Northern Nigeria have been solely harvested from the north (for now at least).

8.4. Chapter Summary, Critique and Conclusion

8.4.1. Chapter Summary

This chapter set out to explore household fuelwood use in relation to the findings in chapters 4 and 6. This was achieved using a questionnaire that was designed to seek answers from households who are the dominant users of fuelwood in Nigeria. The responses generated were coded and further explored using cross tabulation. The discussion of the resulting outcome was believed to have highlighted many situations relating to fuelwood use strategy in the study area in accordance with the questions originally posed in chapter 7: 7.2.1 as follows:

- a) Does seasonal or protracted fuelwood scarcity have significant socio-economic effects on households?

From the findings of this chapter, there is high demand and consumption of fuelwood in the study area. Also, the families are already facing difficulties in terms of fuelwood procurement, where the majority of them buy their fuelwood from the vendors at higher prices. In addition, the majority of the families spend a substantial amount of their

monthly income on the purchase of fuelwood while the few that fetched their fuelwood from the common forest using family labour reported that they travel long distances in order to fetch the wood.

One of the new findings observed in this study that was not reported in earlier literatures is the procurement of fuelwood in the northern part of Nigeria that involved young children “*Almajiri*” who fetch the wood for their personal economic benefit. However, this requires further investigation. The actual reality of the situation is still unsubstantiated, because this study has identified it for the first time. Another finding is the report on tree ownership among some households in Nangere area, where the majority of the households argued that owning more trees on their farmland alleviates fuelwood hardship.

The study (like its predecessors) also revealed that regardless of the variation of the seasons in a typical year, the majority of the households rely on fuelwood. However, most households use more fuelwood in the harmattan season than other seasons of the year largely because of the additional requirements for heating and boiling of water for bathing. The study also found that more fuelwood is used during festivals and occasions such as child birth, as described in section 8.3.1.2.

In contrast to the high demand or use of fuelwood in the harmattan season, the majority of the households believed that the prices are higher during the rainy season than the other seasons of the year. Part of the reason for this was the poor condition of the access roads leading to the procurement areas and the temporary changing of engagement by the fuelwood labourers in farming activities.

b) What is the relationship between fuelwood consumption and the availability and prices of petroleum products?

Although there was considerable interest among households in switching over to the use of modern fuels in the study area, the high cost and unreliability in the supply of the modern fuel was among the reasons for the continued dependence on the use of fuelwood particularly among households with less than 6 persons. Overall, the cost of fossil fuel in the study area is always high because the households rely on the “black market” for their supply, which is far more expensive than the commodity at official pump prices.

8.4.2. Conclusion

Even though the sample size (128 households) used in this study was quite small, increasing the number would not probably have greatly impacted the outcome of the overall findings. This was because the result presented so far did not vary much from what Alabe (1996) obtained from his study in Yobe and Borno states using more than 1,500 household samples in each of the two states, or the results recently presented by Maconachie et al. (2009) in Kano in their two surveys in 2006 using 576 household samples and in 2002 using 100 households samples.

Overall, this study once again reiterated the importance of commercial fuelwood vendors in active deforestation, because they are the main suppliers of fuelwood in the study area. This necessitates the exploration of the activities of the fuelwood vendors, as part of the wider fuelwood study progress of this study, in order to further understand their potential contribution to deforestation in greater detail. Thus, the next chapter (chapter 9) presents the results and discussions of fuelwood vendors' activities as part of the continued fuelwood investigation in this study.

Chapter 9: The Strategy of Fuelwood Supply - An Overview of Commercial Fuelwood Activities

9.1. Introduction

The discussion in chapter 8 revealed that households in the study area relied on fuelwood vendors for their supply. As such, fuelwood vending is assumed to be a product of the fuelwood scarcity situation in order to meet the increasing demand among households. However, the continued clearance of the limited vegetation by commercial fuelwood vendors has been reported as a potential threat to the environment (Amacher et al., 1996; Adeoti et al., 2001; Mahiri, 2003; Madubansi & Shackleton, 2007; Bearer et al., 2008; Bense, 2008 & Christensen et al., 2009). This is true if one considers the fact that in the majority of the Developing Countries (DC) where fuelwood was considered an option for cooking, woodlands are treated as an open access resources (common property) (Chomitz and Griffiths, 2001; Linde-Rahr, 2003 & Hiemstra-van der Horst & Hovorka, 2009), where users over-exploit it, with no regard to its future sustainability.

Even though there were indications of over-exploitation of vegetation resources by fuelwood vendors, the few benefits of their activities (such as creating employment) were most often overlooked by researchers.

This chapter presents the results of commercial fuelwood activities, in anticipation of finding answer(s) to the questions raised in chapter 7: 7.4.1, using the data generated from six different groups of vendors (see chapter 7: 7.4).

9.2. Structure of Commercial Fuelwood Vending

9.2.1. Labour Division

The evolving literature on the activities of commercial fuelwood supply suggests that the increasing demand for fuelwood has attracted several people into its trading. A number of vendors interviewed discussed the structure of the fuelwood business which differed in terms of labour division and/or the nature of the engagement in the procurement process. These are summarised below:

- a. Main owners or Dealers: These are the sole owners of the business who own a shed in the market (informal office mostly made from local materials) and coordinate the business from there. The dealers sell the wood in either of the three forms below:
1. *Gudubale*- These are tree trunk or big logs of woods (purchase as a trunk of wood and then split into pieces).
 2. *Tsarnu*- These are long tree branches, mostly for construction (local roofing). There is a strict law governing the collection of *Tsarnu* which is mostly obtained from the neighbouring Gombe state (see box 9.1 & plate 9.1 for detail).
 3. *Shaftare* or *Dami*- These are fuelwoods that are sold as bundles. They may either be from small branches of trees or logs that have been split.

Box 9.1: Wood Collection in Wawa Forest of Gombe State

There is a strict law governing the clearance of live trees in the study area. However, pockets of dense vegetation areas around the area are experiencing massive deforestation (Odihi, 2003), which the government now enforced even a more authoritarian measures through its forestry workers in order to curtail the deforestation activities. An example of such vegetation areas (with such tougher measures) are Buni yadi forest in Gujba LGA in Yobe state and Wawa forest in Dukku LGA of the neighbouring Gombe state. For example respondents one and two showed that the only place to get *Tsarnu* around (shortest distant place- see section 9.2.5) is Wawa forest. Respondent one related that *"the law governing its collection is very tough... and the collection is mainly done at night when forestry officials are not on duty*. He narrated that one of his members (he pointed one of them to me - before he continued)... was recently arrested, detained and molested badly for two days in Gombe when the forestry officials caught him with *Tsarnu* in Wawa forest.... *It was only due to the effort and intervention of the fuelwood vendors association of Potiskum that saved him from being prosecuted after we pay a heavy fine to the government officials on his behalf"*. Refer to plate 9.1 for photos of *Tsarnu*.

- b. Professional fuelwood harvesters: Respondent number four described that he organised and managed about 10 people: *"I am coaching them to be professional fuelwood cutters. They follow me to the forest as apprentices. We cut the trees from the forest and sell a full truck to either the vendors or directly to the people who wish to buy in bulk.... I have a government official certificate of approval to conduct this business..... We sometimes pay "bribes" to the government officials (revenue collectors)"*.
- c. Splitters: These are the group of people (mostly labourers) that split the logs when it reaches the market from the forest for selling as bundles. They are labourers who are hired to split the logs of wood.

- d. Forest cutters (*"Masu Saraa - a Daji"*): These are the group of people that enter the forest and cut the trees.
- e. Labourers / Assistants: They either work in the market or go to the forest and fetch the fuelwood. They also help with loading and unloading of fuelwood both in the forest and the market.
- f. Remnant Pickers (*"Kale or Tsince"*): These are the group of people that picked the abandoned pieces (remnants) of fuelwood in the market after the logs have been splitted.
- g. Borrowers: Those that take fuelwood as a credit from the vendors and return the money after they sell the fuelwood. The vendors normally give the fuelwood to these categories of people at a discounted price based on personal trust.
- h. Distributors: Those that market the fuelwood locally either in a wheelbarrow or smaller trucks.
- i. Household sellers: Those that sell the wood in their homes (mostly women). These women either collect (borrowers) or purchase the wood at a discounted price from the vendors.
- j. Wheelbarrow Pushers (*Maasu Baro*): They are responsible for the distribution of fuelwood to the various households (when they buy the fuelwood from the market in bulk) in the town.
- k. Drivers and their assistants: These are the people who drive the vehicles. They either lend themselves for hire or engaged directly in the procurement of the fuelwood from the forest where they purchase it from the labourers in the forest. For example, Respondents number five and six mentioned that: *"we use a vehicle to travel to the forest. Sometimes we cut and gather the wood by ourselves. However, most often, we buy from the people we meet in the forest (labourers) who have already gathered it... We buy a full truck (Delta) at 4,500 Naira (about £18) (Delta - is a local name of a particular type of a small truck used in the study area), and we sell for 7,000 Naira (about £28). We then share the money (profit) among ourselves"*.

Note: The labourers (workers), assistants, splitters and forest cutters get between 600 and 700 Naira daily (about £2.40p and £2.80p). See section 9.3.2 for more discussion on the viability of the business in creating job opportunity.

9.2.2. Tools Used in Processing Fuelwood in the Study Area

The processing of fuelwood in the study area relied on the manual use of simple tools such as axes, chisels, diggers and hammers (refer to plate 9.1 & 9.2 for illustrations).

All the six groups of vendors confirmed that they use manual labour throughout the processing of fuelwood with no machinery (like a chainsaw).

- Axe is used for cutting the trees in the forest and splitting the dry wood after it was brought to the market.
- Chisel is used for splitting big log of dry wood in the market.
- Digger is used for digging the root of the tree especially the dry wood of *Bauhinia rufescens* "(Jalahe)" in the forest.
- Hammer is used for driving the chisel dip inside the log of wood for easy splitting.

9.2.3. Reasons for Participating in the Business

Fuelwood vending as described by all the six groups of vendors serves as an employment opportunity to support their families. However, they have all portrayed the business as a tough one, because it requires intensive manual labour. On the other hand, they have all reported that they also engage in farming activities during the rainy season.

Respondent number four for example, added that: *"for me it is a full time job that I inherited from my father, who coached me to be an expert fuelwood collector..., I started the Job since I was 15 Years old"*. On the contrary, respondent number five mentioned that: *"I only participate fully in the business on a weekly basis (on market days which is every Tuesday in Nangere town)"*.

Respondents four and six further commented on other reasons that attract them to the business as follows: *"to supply fuelwood to the people... because it is the only alternative source of cooking fuel for the ordinary people"*.



Plate 9.1: Processing of Fuelwood in the Market

From top left, top centre and top right are photos of Tsarnu in the market; bottom left and bottom centre are labourers processing fuelwood (splitting big logs into smaller pieces). Bottom right is the pieces of wood after processing. Source: Author's field trip, 8th October, 2010.



Plate 9.2: Photos of the Type of Tools Used in the Processing of Fuelwood

From top left is a wheel barrow pusher; top right is myself and some labourers during one of my visits; bottom left and right are axes, chisels and hammer used in processing fuelwood. Source: Author's field trip, 8th October, 2010

9.2.4. Profit of Fuelwood Vending

The business of fuelwood according to the vendors is faced with interruptions in certain seasons of the year and the profit was considered less during those periods. Overall, all the six groups of vendors concluded that the business is more profitable in the rainy and harmattan seasons than the hot dry season. However, some of the vendors revealed some interesting observations (in Nangere town) as follows:

Respondent number three mentioned that: *“the business is not profitable after the harvesting period when the Fulani nomadic cattle rearers from neighbouring Niger Republic (Udawa- with their large cattle flocks)²⁷ used to visit the area on their way to the south in search of a greener pasture for their cattle”*. They cut the branches of any edible tree on the farmlands in order to feed their cattle. After they left, the farm owners collect the wood and use them as fuelwood. *“This situation reduces our chances of getting more potential buyers, during that period”*.

On the other hand, (Respondents number five and six), mentioned that: *“fuelwood is a profitable business because it is free and readily available if you know your ways”*. *“The only difficulty is the cost of hiring a vehicle”* - Respondent number six.

Respondent number four mentioned that: *“fuelwood business is not profitable these days when compared to a few decades ago... especially with the introduction of a local voluntary vigilante organisation called Yan Kungiya (Kungiya is a local name meaning- a group; OR Yan kungiya, which refers to group members). The group is a local community organisation in Nangere area that discourage the excessive deforestation in the forest.... They are more vigilant of the forest trees than the government officials... The group used to levy a heavy compulsory fine on us..., and if you fail to pay the fine, they confiscate the wood and sometimes even your tools.”* Respondent three (from Nangere town) also confirmed the activities of *Yan Kungiya*. He further stated that they are more confined to Yobe state (because he has not heard of their existence in any of the neighbouring states) and that; he does not know their source of revenue since they are not government

²⁷ The Udawa normally operates in a hostile manner and most often invade the farms even at the disapproval of the farmers. However, sometimes the farmers allow them to stay temporarily on their farms so that their animal dung's can serve as manure to the farmlands (a kind of symbiosis relationship). In the case of this particular situation in Nangere, the farmers are not usually happy with the cattle rearers' operation, because in the process, some of the remains of their farm produce are also being destroyed as confirmed by one resident. Refer to chapter 10: 10.4.1.4 for more detail on the conflict of grazing land in Nigeria.

officials. Even though the two group of vendors in Nangere confirmed the activities of *Yan Kungiya* in their domain, none of the vendors interviewed in Potiskum town mention them as being an obstacle to their fuelwood procurement strategy despite all having knowledge of their existence (N.B, all my efforts of finding any member of the *Kungiya* to comment on the allegation, failed).

9.2.5. Distance to Fuelwood Procurement Centres and the Type of Vehicles Used in Conveying the Goods

The distance that the vendors travel in order to procure the fuelwood ranges from 25 km to 200 km (see figure 9.1).

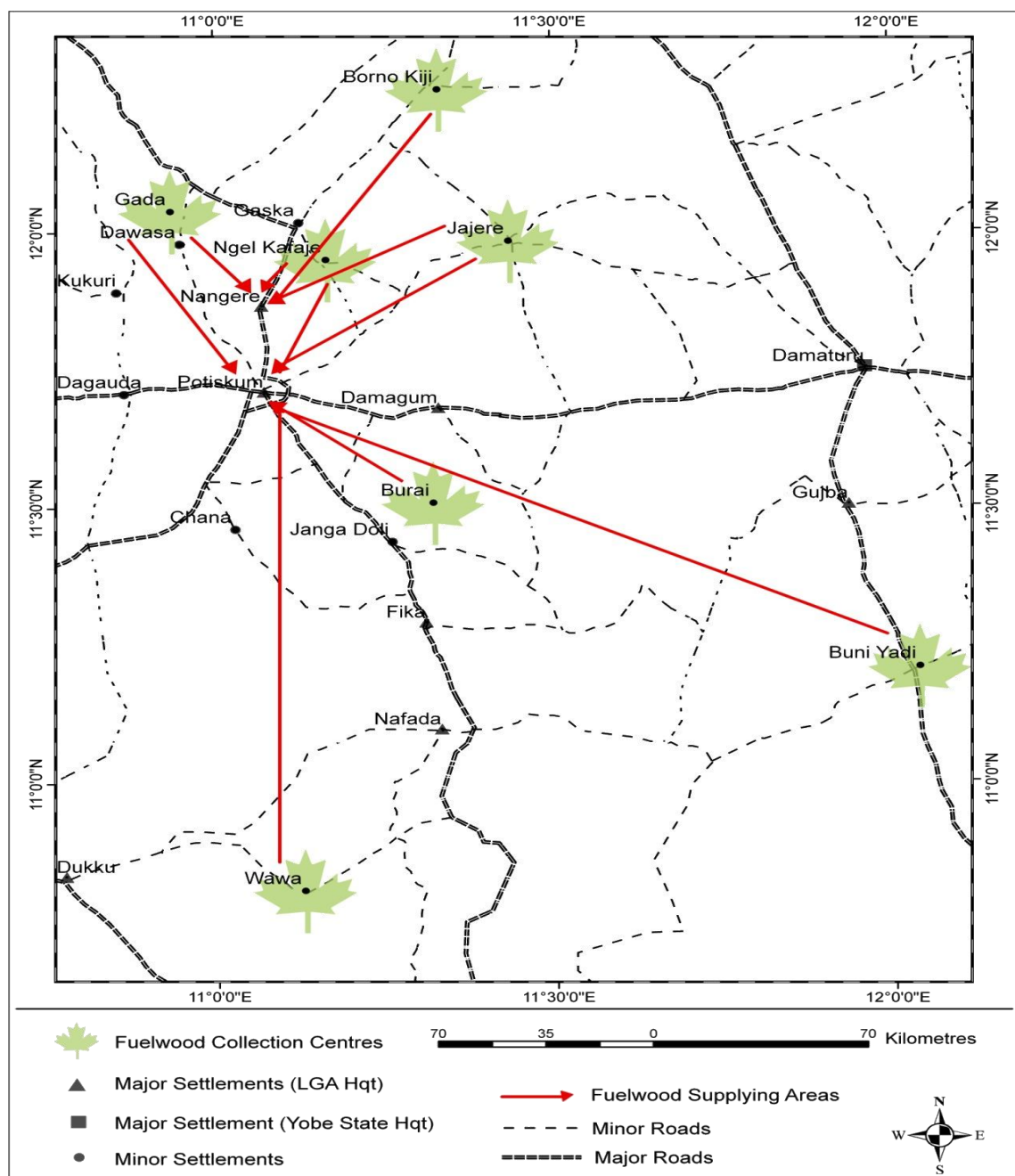


Figure 9.1: Fuelwood Procurement Centres

The following areas were cited by the vendors in their respective comments as their collection centres.

- “Buni Yadi” forest in Gujba LGA of Yobe State- about 170 km away from Potiskum (Respondent one- Potiskum vendors).
- “Ngarfo” forest- Jajere area in Fune LGA of Yobe State- about 130 km away from Potiskum (Respondent one- Potiskum vendors and Respondent three- Nangere vendors).
- “Kafage” forest- in Fune LGA of Yobe State- About 60 km away from Potiskum (Respondent six- Nangere vendors)
- “Borno kici” forest- Fune LGA of Yobe State - about 50 km away from Potiskum (Respondent three- Nangere vendors).
- “Kayeri” forest- in Fune LGA Yobe State- about 60 km away from Potiskum (Respondent one- Potiskum vendors and Respondent four- Nangere vendors).
- Forest near “Gada” Village- in Fune LGA of Yobe State- about 50 km away from Potiskum (Respondent three- Nangere vendors).
- “Burai” forest, near “Jangadole” Village- in Fika LGA Yobe State – about 40 km Away from Potiskum. Difficult terrain to harvest wood (depression) (Respondent one and two- Potiskum vendors).
- “Wawa” forest- in Dukku LGA of Gombe state – about 160 km away from Potiskum (Respondent one and two- Potiskum vendors).

It is worth noting that all the vendors acknowledged that: *“the collection is mainly in connivance with the forestry authorities (using bribes)... and also that the distance to collection centres have increased in recent years, which is why they have to travel much further than they use to do in previous years (see section 9.2.5 for more detail), particularly Wawa and Buni Yadi forest are new collection centres according to respondents one and two”*. The result of chapter 4 (Remote Sensing (RS) imagery results that show a vegetation decrease from 1978 to 2005 in the study area) has also been confirmed by the vendors who narrated that they now have to cross their local administrative boundaries in order to procure fuelwood, which is why only two of their present collection centres (Ngel Kafaje and Gada (north of Nangere - Figure 9.1) appeared on the RS image results, where the vegetation of the two areas also appeared to have drastically declined from 1978 to 2005.

Due to the distance to the procurement centres, lorries and small trucks were used to convey the fuelwood to the market. The choice of the vehicle depends on the size of the load and the nature of the terrain leading to the collection centre. Below is a list of the types of vehicles used in conveying the goods from the forest area (see plate 9.3 for illustrations):

- “Delta” or “Kanta”- (Respondents one and two- Potiskum vendors and Respondents three and five- Nangere vendors).
- “Pick up”- (Respondent two- Potiskum vendors and Respondent four- Nangere vendors).
- “Beijin”- it is bigger than an animal cart – (Respondent four Nangere vendors).
- Big Trucks - (Respondent two- Potiskum vendors- See plate 9.5 for photo).

9.2.6. Price of Fuelwood

The selling of fuelwood is organised in the following format:

- The fuelwood is conveyed in vehicles from the forest in different ways which mostly depends on the type of goods to be delivered. For example, if a big truck is used in conveying the wood, the fuelwood is arranged in lines (a line is how the fuelwood is structured in the lorry). A big truck carries up to 4 lines which are distributed to the vendors. Some vendors buy the whole lines, while others buy a line and distribute it as chunks. A line cost about 8,000 to 12,000 Naira (about £32 to £40).
- Logs are split and sold in terms of size and number (5 small pieces cost 20 Naira (about £0.08p).
- Bundles cost around 100 to 130 Naira (about £0.40p to £0.52p) (depending on the size of the bundle).
- Chunks or pile of fuelwood- They cost around 500 and 1000 Naira (about £2 and £4) (depending on the size).
- All the six vendors confirmed that the quantity and quality of the wood are very important in determining the price of fuelwood. The following observations were also highlighted by the vendors.
- Respondents three and six mentioned that: *“there is no specific/ standard measurement of price- we are able to sell to buyers for any amount from 20 Naira and above... any amount can be bought”*.



Plate 9.3: Photos of the Types of Vehicles Used in Conveying Fuelwood

From top left and right is *Delta* or *Kanta*; bottom left and right is a *pick up*. Source: Author's field trip, 28th July 2010

Respondents four and five mentioned that: *“we deal with bulk merchandise, so we charge 7,000 Naira (about £28) per full truck (Delta) and 3000 Naira (about £12) per Bejin”* (see section 9.3.4 for more detail).

Respondent six mentioned that: *“some customers buy the full truck of fuelwood directly from us. However, the majority of the people can only afford a small quantity. We therefore split the wood into small pieces and sell in small quantities”*.

From the price range of fuelwood highlighted above, fuelwood appeared to be the only form of cooking energy that can serve the needs of even the poor households, as demonstrated by many households in chapter 8.

9.2.7. Fuelwood Business and Taxation

Although all the respondents reported that they pay a certain amount of money to the government authorities as tax while conducting their businesses, they also lamented that most of the money they paid were in the form of bribe. Below are the two types of tax being paid by the vendors, as well as some examples of the fraudulent activities impeding the taxation system.

1. Market sheds revenue- This is a tax payable to the Local Government Revenue officials for possessing a shed to conduct the business in the market. It is normally a weekly payment of 100 Naira (about £0.40p) if the shed is permanent or 50 Naira (about £0.20p) if the shed is temporary.
2. Forest revenue- This is a tax payable to either the Local Government Area (LGA) or the State Government (SG) through the forestry workers in the forest. *“The money we pay does not normally reach the government account because we sometimes pay up to 3,000 Naira (about £12) per truck (depending on the type of vehicle) to be allowed into the forest to fetch fuelwood and the officials only issued us with a receipt of 300 Naira (about £1.20p)”* (Respondents one, two, three, four & five). Respondent one also stated that about 300 Naira is charged per labourer by the forestry officials in some forest in order to gain access into the forest to fetch fuelwood. Respondent five further confirmed that: *“if one tries to cut corners and is caught, there is a heavy fine of 5,000 Naira (about £20) levied by the forest workers (locally referred to as Malaman Daji)...mostly as a bribe because they do not issue a receipt for that either”*. Refer to box 9.1 for more detail.

Contrary to all the aforementioned confirmation by respondent five, a few of the respondents acknowledged that they sometimes cut corners and take their chances. Respondent three for example, had this to say: *“even though we operate under a strict law by the government, we do not normally pay this tax..... We take our chances....., but if caught, the government officials will either put a heavy fine or prosecute us in a court of law, which in most circumstances results to imprisonment depending on the nature of the offence”*. Overall, the collection of receipts by the vendors does not symbolise any form of patriotism to the government, since it is the same government officials that manage the forests. This statement was discussed by Respondents four and five who mentioned that they pay around 500 to 1,000 Naira to the officials in the forest: *“sometimes we collect receipts, but we do not normally collect the receipt because it is worthless”*- (most of the payment actually made is a bribe).

9.2.8. Seasonal Variation in Price and Activities of Fuelwood Procurement

As identified in chapter 8 (household survey), the cost of fuelwood fluctuates seasonally. The vendors also confirmed that the market price of fuelwood is determined by the season. For example, the rainy season and harmattan seasons are the most profitable seasons in terms of fuelwood purchase compared to the hot dry season when the purchase price drops low. The Rainy season purchase is higher because of the low supply from the forest due to inaccessibility of the roads leading to the collection sites (seasonal floods). Below are examples of how the respondents narrated the situation.

All the Respondents agreed that the rainy and harmattan seasons are the two seasons when fuelwood price is high (there is an increase of about 30 to 40 percent from the usual price sold in other seasons), which make the business more profitable. While Respondent four only considered harmattan season as the best season for the business. Respondent five mentioned that: *“rainy season is a good season for selling fuelwood, because the commodity is in high demand and therefore sales are high., the main strategy of meeting the demand of this season is through hoarding”*. See more discussion in section 9.3.4.

The two most marketable fuelwood types in the highest demand according to the vendors are as follows:

1. "JALAHE"- More marketable in the rainy season because of its high combustion (it is considered to be more expensive).
2. "MARKE"- More marketable in all seasons except the rainy season because of its good combustion.

Note that these two species of fuelwood are also among the list of most preferred fuelwood highlighted by the households (refer to chapter 8: 8.3.3.1).

While fuelwood pricing is higher in the rainy season, the activities of fuelwood collection are higher in the dry season, which the vendors related as follows:

1. Rainy season- This is a difficult season for the procurement of fuelwood, because the roads leading to the inner forest are inaccessible due to seasonal flooding which makes transportation difficult (earth roads – refer to chapter 8: plate 8.1). As highlighted in chapter 8: 8.3.1.2, other issues affecting the procurement of fuelwood in the rainy season is the farming activities. During the rainy season, the majority of the labourers that process the wood (see section 9.2.1) move on to "*Barema*" - paid rainy season casual jobs in the farms (All Respondents).
2. Harmattan season- This is a good season for the procurement of fuelwood because of its availability (no restrictions as in the rainy season) and there is high demand for fuelwood. Therefore, trading in this period is also profitable (All Respondents).
3. Hot season- (Normal activity) - This season is not good for the business of fuelwood in terms of selling, because the demand is less (All Respondents). However, the stockpiling (hoarding) of fuelwood for use in the rainy season occur in the hot season. The hot season was therefore regarded as the best season for the procurement of fuelwood.

9.3. Discussion of Results

9.3.1. Mode of Commercial Fuelwood Operation: A Field Trip Experience

Amatya et al. (1993) disregarded the active practice of commercial fuelwood in the rural areas of the DC by pointing out that the commercial use of fuelwood is only confined to the urban areas, where fuelwood is monetised. However, evidence from this study, contradict that view, because Nangere town (which is more like a rural area), in the study area practice full scale commercial fuelwood vending. Therefore, the current nature of

fuelwood collection in the study area has changed to a commercial activity even in the rural areas, because of the variety of engagements and the job opportunities it creates (see section 9.2.1). Overall, the common features of the varied activities reported in section 9.2.1 among all the fuelwood business operators are that they all use simple tools in the procurement and processing of fuelwood (see plates 9.1, 9.2 above and 9.4 below). This finding was contrary to the initial assumption of the researcher who thought that the vendors are using sophisticated tools (chainsaws) in the processing of fuelwood as speculated in chapter 2: 2.3.4.

Another important observation made in the business that was not reported in earlier literature can be illustrated from the author's personal engagement with the vendors during a field trip on 26th July, 2010. As part of my inquiry during a conversation with the commercial fuelwood vendors' chairman of the Potiskum central market, I was told that there are two major modes of fuelwood collection strategy. One is locally called "*Dandi*" and the second one is called "*Daba*". These two collection strategies are discussed below as observed in the field using some photographs taken (plates 9.4 & 9.5 respectively) to demonstrate the level of the activities.

9.3.1.1. Modes of Fuelwood Collection Operation "*Dandi* and *Daba*":

Dandi is the kind of collection operation where the workers that engaged in the procurement of fuelwood, hire a vehicle for a day trip. They normally leave in the morning, and return to the town in the evening for onward selling of the wood to the market vendors. This operation is very popular among labourers, who organised themselves (ranging between five to ten people), and travel into the forest, in order to supply the wood daily. A trip to *the Burai forest* near *Jangadole Village* (Latitude 11.460734 N, Longitude 11.329507 E), south of Potiskum town on the 27th July, 2010 improved my understanding of the operation. The fuelwood collected from this forest are the remaining roots of a dead tree (*Jalahe*), which had been cut down previously (many years back). The operation involves digging the ground in order to uproot the remains of the dead tree stump. The mode of operation of this particular collection site was obviously laborious as can be observed in plate 9.4. The workers spend less time looking for the dead stump (approximately 10 minutes) before digging it out which also last between 10 to 15 minutes depending on the size of the dead stump. Note that the operation I observed in this particular forest does not involve cutting down of live trees.



Plate 9.4: A visit to Burai Forest

From top left, is the vehicle hired full of the labourers; top centre and top right are photos of the dead stumps in the forest; centre left to right are labourers digging out the remains of the dead tree root; bottom left is a labourer collecting the harvested wood ; bottom centre are the collected wood gathered near the vehicle before the final arrangement; and bottom right is myself with some of the workers at the background. Source: Author's field trip, 27th July 2010.



Plate 9.5: A visit to Wawa Forest

From top left and top centre are evidence of fresh leaves and wood, top right and middle left is me discussing with some of the workers. Middle centre and middle right are small truck tracks leading into the inner forest. Bottom left is a small truck off-loading the collection from the inner forest, while the bottom centre and bottom right are labourers loading fuelwood unto a bigger truck and a bigger truck full of fuelwood.

Source: Author's field trip, 12th October, 2010.

Contrary to the *Dandi* mode of collection operation, the *Daba* collectors remained in the forest for a number of days (sometimes weeks) in order to stock enough wood that can be collected using a bigger truck for onward delivery to the market in the towns. This kind of operation is very popular among the influential vendors who encouraged the collectors by supporting them with all the necessary material assistance (food and advance payment for the goods). Refer to plate 9.5 above for illustrations.

My initial arrangements with the vendors to observe the conduct of the *Daba* operation in Buni Yadi forest of Gujba LGA in Yobe state on 2nd August, 2010 and “Wawa” forest in Gombe state on 10th October, 2010 failed. The visits were cancelled due to lack of someone that could guide me in the forest. Upon further inquiry, the “*Sarkin Dajin Fika*” (the traditional chief of the forest of Fika emirate council) offered to guide me to “Wawa” forest on the 12th October, 2010.

The “Wawa” forest is located at Latitude 10.819698 N and Longitude 11.033342 E and about 160 kilometres south of Potiskum town. The fuelwood collected from this forest is a combination of both live and dead trees. From plate 9.5 one can observe an evidence of fresh wood left-over leaves, and tyre tracks of vehicles leading to the inner forest. The tracks were created as a result of fuelwood collected from the inner forest. These workers stay in this forest for weeks in order to gather the fuelwood. They then call their vendors who live in the cities to organise and move the fuelwood from the inner forest (using smaller trucks) to the collection centre ‘*Daala*’ (Local name, meaning Pyramid). As soon as there is sufficient fuelwood in the *Daala*, a bigger truck is hired to collect the entire load for onward delivery to the cities. This particular load was on its way to Kano city, which is about 400km away from this forest (see section 9.3.3 for confirmation).

The two modes of fuelwood collection operations (*Dandi* and *Daba*) demonstrate the effectiveness of the vendors in maintaining the supply of the commodity to the households. Although both collection strategies concurred with the existing literature on the role played by distance in the creation of commercial fuelwood vending, in my opinion, the sector needs to be appreciated and recognised by the policy makers in order to strengthen the positive aspect of it (policy wise), because of the variety of unskilled jobs it created (about 100 people within the 6 groups interviewed)²⁸.

²⁸Note that this study is not offsetting this against the consequences of environmental damage caused by the vendor’s action (see more discussion in chapter 10).

9.3.2. The Fuelwood Business as a Form of Employment Opportunity

Although commercial fuelwood activity is seen as a factor determining the scarcity and severity of the fuelwood situation in the DC (Christensen et al., 2009), the viability of the industry in terms of job opportunity and poverty alleviation was overshadowed in the existing literature²⁹. This study concurred with Shackleton et al.'s (2006) suggestion on the relevance of the industry as an organised business that provides job security for many families. This can be illustrated from the total number of the existing employees found within the six groups of vendors interviewed here. This high number of people is unsurprising, given that for example, the various categories of job opportunities in the fuelwood industry presented in section 9.2.1, shows the viability of the industry to the uneducated (who do not attain any level of western educational qualification); because the basic requirement for engagement with most aspects of the business is the physical ability of the person (using simple tools)³⁰. The tools used in the processing of fuelwood both in the forest and the market, are simple hand tools (refer to section 9.3.1).

Another potential reason for the high number of people in the business as reported in sections 9.2.5 and 9.2.7 is the profit involved as a result of a conspiracy between the vendors and the government officials through bribery. The procurement of fuelwood in the study area is full of bribery and corruption allegations, because the vendors are scared of the forest officials who have the powers to prosecute them (see chapter 4:4.2.3 & appendix 5). In contrast, the forest officials (who are faced with difficulties that ranges from poor funding to inadequate training and lack of exposure to modern forestry techniques - FAO, 2003 & FAO, 2010; refer to chapter 2:2.2.1.1 for more detail) exploits their mandate of protecting the forest by collecting bribe from the vendors, who are regarded as the culprits. This provides a favourable avenue for the symbiotic relationship that exists between the two parties. However, in my opinion, the bribery allegations in

²⁹ This was earlier highlighted by Porter et al. (2007 p.115) in their study of Market institutions and urban food supply in West and Southern Africa, where they emphasised the importance of *"understanding market institutions as a result of Africa's population increase and how the topic has received little attention from policy makers and researchers despite the implications of market institutions and regulatory systems for livelihoods and poverty"*.

³⁰ There was no reported evidence of bank loans received by any of the respondents. It can therefore be argued that the fuelwood business operation is purely based on trust and the fuelwood vendors' organisational guidelines (which is not a written document). A similar situation was also reported among the vegetable producers and traders in Jos (Porter et al., 2003; Porter et al., 2007 & Lyon & Porter, 2009).

the business needs to be addressed and the business of fuelwood vending should be legitimised by the government and regarded as an advantage to the economy of the people, through proper organisation of the business³¹. A model was proposed by Chomitz and Griffiths (2001) in N'Djamena, Chad; and by Shackleton et al. (2006) in South Africa for the management of the vegetation of the respective countries, which integrates all the stakeholders (including the vendors) in the programme. Although the success of these models are yet to be assessed; a similar approach can be modified to suit the Nigerian context, given that the commercial activities of fuelwood will be inevitable especially in the northern part of the country in the near future (refer to chapters 6 ; 8 & Maconachie et al., 2009). The author proposed a model (refer to chapter 10: 10.4.1.2; figure 10.3 for more detail) that could be of great importance for regulating the existing uncontrolled deforestation pattern of the remaining vegetation cover in the north.

9.3.3. Transportation System Used in Conveying Fuelwood

As suggested by Cooke et al. (2008); Christensen et al. (2009) and confirmed in chapter 8 of this study, the old orthodoxy of African women and children as being the primary collectors of fuelwood is losing ground in the wider fuelwood supply strategy, due to the present long distance travel involved in the procurement of fuelwood in the majority of African countries. The supply of fuelwood in the study area was observed to be an organised pattern that took advantage of the scarcity of vegetation within shorter distances from the towns (see results of chapter 4), in order to maintain the supply to the already existing market.

This study (section 9.2.5) also coincided with the findings of McClintock (1987); Cline-Cole et al. (1987) and Christensen et al. (2009) who indicated the use of trucks in their respective study areas as a means for transporting the fuelwood goods from the distant forest to the towns. Cline-Cole et al. (1987) for example, described the supplying distance hinterland of Kano's fuelwood to have extended up to a radius of 600km, with the highest daily supply of about 425 tons (see chapter 8: 8.3.1 for more detail) in the hot dry season (March-April) of 1983. This was also confirmed in this study, where all the vendors acknowledged that the hot dry season is very good for stocking the wood as against other

³¹ *"In Nigerian, government-related regulatory agencies have been associated with widespread corruption, which has led to loss of trust in these forms of institutions by the public. They have been abandoned where possible in favour of parallel non-state forms of regulation that encourage institutional-based trust such as trader associations and transport unions"* (Lyon & Porter, 2009 p.906).

seasons. However, it was not clear in Cline-Cole et al.'s (1987) observation whether the total supply of fuelwood to Kano from the distant places in 1983, was consumed or stockpiled to cater for the rainy season periods, as presently observed in this study (refer to section 9.2.8).

Conversely, the distance and volume of the fuelwood determine the type of truck to be used for the conveyance of the goods. It is worth noting that distant fuelwood is higher in price as confirmed by one user who bought a full truck. The increase in the price of distantly fetched fuelwood could be a strategy used by the vendors to compensate for the cost of transport since there was not any official regulatory body that manages fuelwood prices. However, on a related development as observed in Kano, Cline-Cole et al. (1987 p.10) revealed that: *“the less populated woodland areas are favoured by specialist traders in firewood, who send trucks in on payment of very small fees to the local authorities (bribery and corruption allegation re-surfaced). After payment for the wood, labour and other costs, profit margins are wide enough to compensate for distance transport costs, at the prevailing retail prices”*. This also indicated the potential of the vendors to exploit the household buyers for their own financial benefit.

9.3.4. Seasonal Change and the Orientation of Fuelwood Business

As highlighted in chapter 8: 8.3.1.2 and section 9.2.8, the business of fuelwood activities varied in terms of the three seasons experienced in the Northern Nigeria (table 9.1).

Table 9.1: The Study Area's Seasonal Variation of Commercial Fuelwood Activities

Season of the year	Procurement activity	Business activity (selling)
Rainy Season	Poor	Excellent
Harmattan season	Good	Good
Hot season	Excellent	Poor

Source: Author's field survey

The outcome of these findings were rationally obvious, given that the need for energy increases during the winter season (Harmattan), while the requirement for energy in the summer reduces (Cline-Cole et al., 1987 & 1988; Alabe, 1996 & Kumar & Sharma, 2009).

Like the findings of Chomitz and Griffiths (2001) and Christensen et al. (2009), the pattern of fuelwood selling (to the consumers) in the study area also differs from one location to another, with no standard of measurement. A recognised form of fuelwood measurement

used by the vendors includes among others; bundles (locally called *Daami*) (see section 9.2.6 for the price range depending on the size).

It was obvious that the fuelwood merchants determine the price of fuelwood, while policy regulation of fuelwood price (as observed in other energy sources like fossil fuel and electricity) were lacking. This situation has left the majority of the households at the mercy of the vendors. In South Africa for example, Shackleton et al. (2006) observed that fuelwood is being sold in many un-standard units of measurement, with the retail prices varying in terms of location, volume of sales, responsibility for delivery and special relationships between the seller and buyer. Thus, the pricing situation of fuelwood in South Africa as reported by Shackleton et al. (2006) coincided with the fuelwood pricing strategy observed in this study.

Similarly, the study area's strategy of maintaining fuelwood supply in the difficult season (rainy season), was through hoarding, which was achieved during the hot dry season. A detail of this was provided during a personal discussion (on 10th October, 2010) with one influential vendor (not from the groups interviewed) who buys and stock fuelwood. He narrated that: *"I used to buy from the vendors.... I start buying from March to May when fuelwood is available because the workers are less engaged in farm activities and the roads to collection centres are accessible.... at this time the market is usually flooded with fuelwood at cheap rate..... I usually buy and stock between 15 to 20 trucks and sell when the price goes up during the shortage periods between July and November. I buy a full truck for 16,000 Naira (about £64) and sell for up to 23,000 Naira (about £92)..."*

Even though from an economic perspective it can be argued that hoarding ties up the capital investment, the case of fuelwood business in the study area was different. This is because apart from the capital gain, fuelwood hoarding has become an integral strategic business option among the vendors to meet the supply of other shortage seasons. And since the mode of fuelwood storage is simple (normally kept in an open space) and does not require any specialised form of storage facility, a profit difference (for example), of up to 7,000 Naira (about £28) per truck (if 20 trucks are sold) could bring around 140,000 Naira (about £560, which is about 44% profit) within a few months time. This profit margin is huge enough to attract more potential investors. It is therefore unsurprising that this kind of business strategy is gaining popularity among the fuelwood vendors, who see it as an opportunity to make more money.

9.4. Chapter Summary, Critique and Conclusion

9.4.1. Chapter Summary

This chapter sets out to investigate the activities of commercial fuelwood vending in order to complement the findings in chapters 4, 6 and 8. This was achieved using a questionnaire that was designed to seek answers from the vendors in the form of focus group discussion where possible. The discussion of the resulting outcome has explained numerous situations relating to fuelwood supplying strategy in the study area in accordance with the questions posed in chapter 7: 7.4.1. Below is a summary of the findings:

- *What are the activities involved in fuelwood procurement? In other words, what type of tools and labour are used in the acquisition process, and how far do they travel in order to meet the high demand of fuelwood?*

Only manual labour and simple tools were used throughout the procurement and processing strategies for fuelwood supply. The vendors sometimes travel up to 200km from Potiskum town in order to supply fuelwood. The majority of the supply centres highlighted by the vendors were outside the local administrative boundaries of the study area.

- *What season of the year is mostly dominated by the activity of fuelwood and why? Is there any relationship between the different seasons of the year in terms of fuelwood demand and price?*

The procurement of fuelwood is carried out in all three seasons. However, the activity seems to slow down in the rainy season due to the difficulty of accessing the forest and the temporal migration of the labourers to farming activities. The demand for fuelwood is high in the rainy and harmattan seasons and less in the hot dry season. However, the hot season was recognised as the best season for stockpiling the wood for the high demand period of the rainy season.

- *What determines the price of fuelwood in the study area?*

The vendors determined the price of fuelwood in the study area. Also, there were no measurement standards, while prices differ in terms of location, quantity of fuelwood and

sometimes personal relationship of the buyer with the vendor. The most interesting thing about fuelwood was the flexibility of the market, because even the poor households can afford to buy the wood.

- *What is the structural system/chain of activity in the commercial fuelwood industry? How is the industry in terms of organisation?*

The activity of commercial fuelwood vending is highly organised in the study area. Even though, there are varieties of jobs in the business, everyone knows what was expected of them in terms of structure. This is illustrated in figure 9.2.

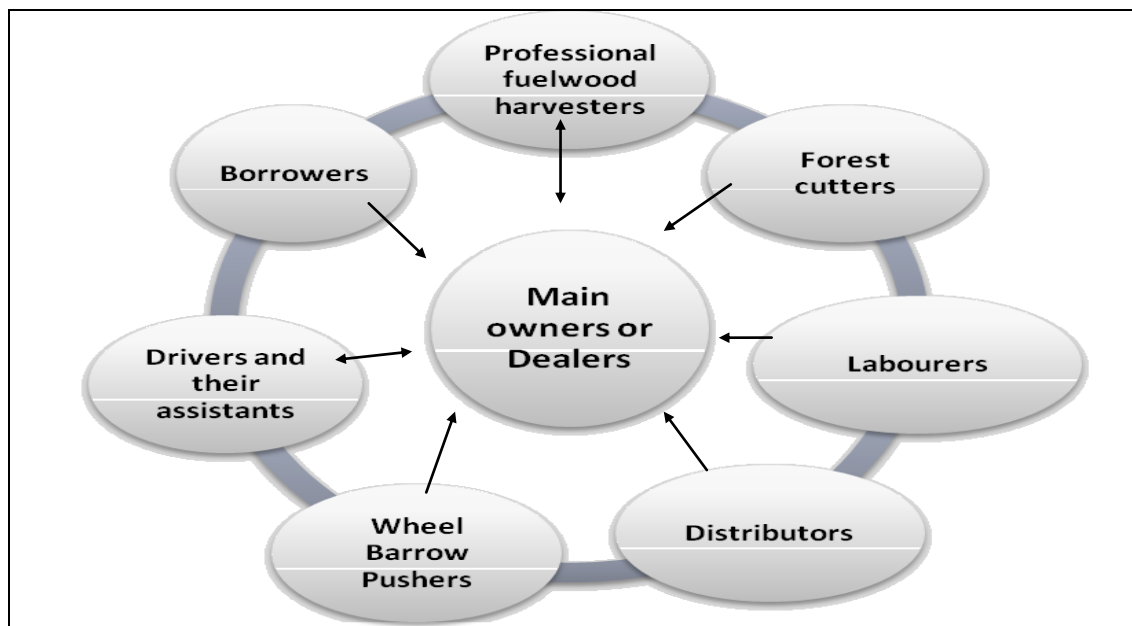


Figure 9.2: Structure of commercial fuelwood organisation

From figure 9.2, the dealers are the key to the business and they tend to steer the activities of all the other jobs associated with the business. Therefore, all the other sectors of the business depend on the dealers. Both professional fuelwood harvesters and drivers can sometimes be the main owners.

9.4.2. Chapter Critique

All the information reported in this chapter was gathered through interviews and personal observation in the field. It is worth noting that the researcher faced some difficulties at certain stages while conducting the exercise. Specifically, some of the vendors' attitudes might compromise the quality of a research of this nature, if not properly addressed. For example, a major issue faced during the field investigation was the unwillingness of the vendors to fully cooperate with me at the initial stage of my visit

(refer to chapter 7: 7.4.4.1). This resulted in increasing the number of my visits and days of stay in order to gather enough information as against my initial timetable plan. Another issue was the attitude of the fuelwood workers (in the two forests I had visited), who failed to show or take me to the actual scene of deforestation (where the big tree logs are being fetched) in the forest, despite evidence of using such logs in the market (see plates 9.1 and 9.5).

A final critique of this chapter might be reflected from the lack of response by the government officials who were accused of taking bribes by the vendors. However, there were many reports (refer to chapter 2: 2.2.0) on the existing negative financial situation of forestry workers in Nigeria, which is one of the reasons why this study also assumes that the vendors allegations were right. Another strong reason for believing the vendors allegation was the fact that we were also offered wood and money (supposedly to top up our vehicle fuel) by some of the fuelwood collectors during our visit to Wawa forest. Upon inquiry from my guide, I was told that they assumed I was a government official who was about to expose their activities.

9.4.3. Conclusion

The collection pattern of commercial fuelwood in the study area, has changed from that of traditional household collectors to an organised trade and from the cleaning of dead woods to the cutting down of live trees in order to meet with the high demand, using simple tools. The collectors are mostly locals who rely on simple modes of transportation systems to travel long distance in order to convey their goods to their buyers. In this way, fuelwood vending is found to provide critical support to their incomes, and a key source of low-cost energy (Hiemstra-van der Horst & Hovorka, 2009). However, this situation was perceived to be a major factor in the accelerated process of environmental degradation (deforestation). Although there are laws enacted in order to discourage both the collection and trading of fuelwood in most DC, little has been achieved to stop this practice, which can be attributed to lack of awareness from the policy makers, of the relevance of commercial fuelwood activities to the economy. Only a few researchers have pointed out the importance of commercial fuelwood in the socio-economic activities of the DC. Therefore, the authorities do not seem to be fully aware of the job opportunities in the business, which this chapter tried to highlight. The next chapter provides some solutions for curtailing the problem of deforestation in the area.

Chapter 10: Recommendations for Curtailing the Problem of Deforestation

10.1. Introduction

The results of the previous chapters have demonstrated the significance of fuelwood among the various cooking fuels used by households in Nigeria. While the consumption of fuelwood in the country is unsustainable, due to the significant reduction of the vegetation of some areas (e.g. the local study area from 1978 to 2005- see chapter 4), the reliability of fossil fuel supply is uncertain (see chapter 6). Although, many reasons were provided to support the observed reduction of the vegetation in chapter 4, of which fuelwood collection and farmland acquisition appeared to be the most noticeable factors among the various reasons provided. Also, among the two most noticeable factors, fuelwood collection is more obvious (Odihi, 2003). As argued in chapter 4, any vegetation cleared in the arid north of Potiskum and its environs is used as fuelwood.

In this chapter, the observations of the local residents of Potiskum and its environs are reported in order to demonstrate part of the wider deforestation issues affecting the northern part of Nigeria. These were obtained through the interviews conducted for the households and the fuelwood vendors (refer to chapter 7; appendix 1 -questions 22 & 23 & appendix 2 - question 17 for details). Therefore, the reader should bear in mind the illustrative position of this chapter and not expect any authoritative estimations of deforestation or avoided deforestation.

The responses to the questions were interpreted and the results are presented in sections 10.2 and 10.3, while the discussion follows in section 10.4.

10.2. Local Households Perception of Their Surrounding Vegetation

Results from chapter 8: 8.1 (k) revealed that about 93% of the respondents have noticed a major reduction of their surrounding's vegetation in recent times. This was further demonstrated in the results of question 22 (appendix 1), and the responses to question 23 (appendix 1 -reported in section 10.3).

Figure 10.1 presents the various respondents' reasons for the potential cause(s) of vegetation reduction.

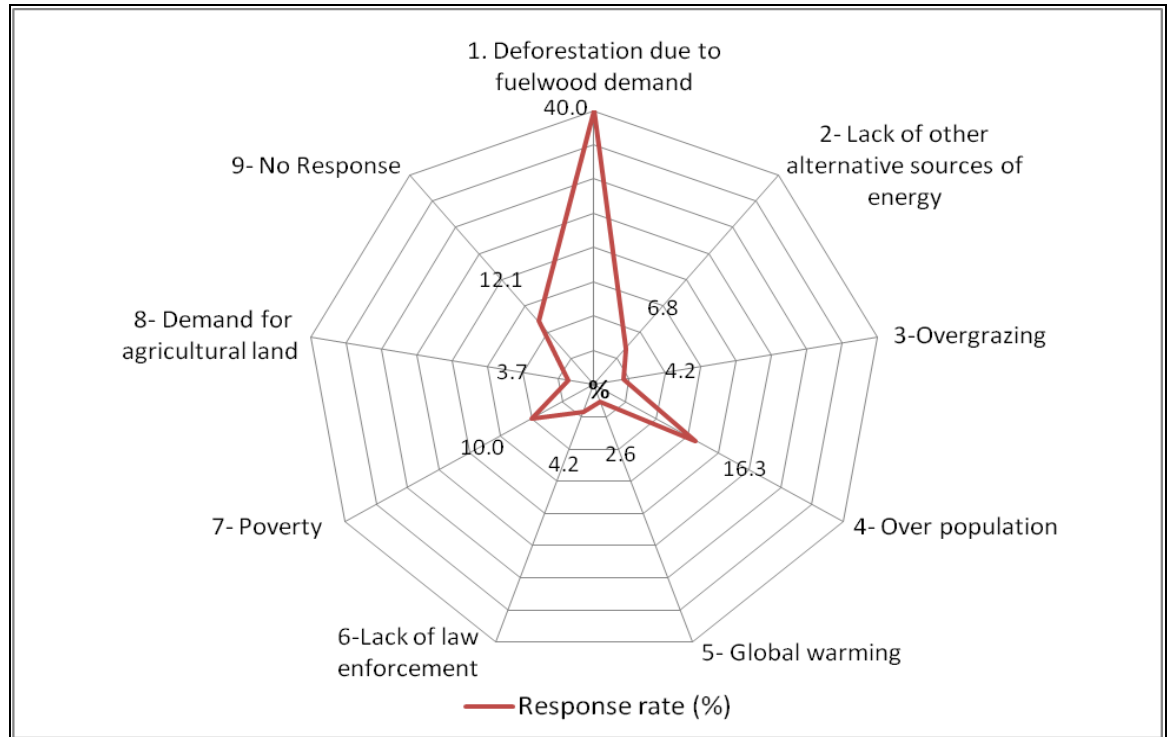


Figure 10.1: Causes of Vegetation Changes

From figure 10.1, the total response rate is about 88%, of which 40% pointed to fuelwood collection as the key factor causing deforestation. Nearly all the respondents described their responses in the following terms: *“very high demand for fuelwood by the households causes deforestation”*; or *“the inappropriate cutting down of trees to meet the high demand for fuelwood without replacing them, causes deforestation”*.

Population increase has been reported by slightly above 16% of the respondents as the cause of deforestation, who emphasised that the size of the population has substantially increased in recent times compared to the past. They claimed that the demand for fuelwood and housing by the increased population, can only be met by the existing vegetation resources, hence the reason for the vegetation reduction. Poverty and lack of job opportunity is reported by 10% of the respondents, who emphasised that the massive unemployment, poverty and lack of support from the government affect the way in which the vegetation is being used. The lack of other alternative sources of cooking fuel is reported by about 7% of the respondents as a factor responsible for deforestation. They stressed that poor supply, and inaccessibility of other sources of fuel attracts more people to use fuelwood, which in effect reduces the vegetation of their surroundings. Interestingly, overgrazing and ineffective law enforcement on deforestation that prior to the commencement of the survey, were assumed to be largely responsible for the majority of the deforestation, were each reported by slightly above 4% of the

respondents as being a reason for deforestation. These respondents emphasised that overgrazing, by the “*Udawa*” (refer to chapter 9: 9.2.4) and “*Fulani*” herders were responsible for deforestation. The ineffective law enforcement (in safeguarding the forest) was demonstrated by the respondents in terms of lack of good governance and the large scale corruption in the forestry regulatory agencies (refer to chapter 2:2.2)

Although the demand for agricultural land was reported in chapter 4: 4.2.1 as one of the two most influential factors of deforestation, less than 4% of the respondents agreed that it has any significant influence on the study area’s vegetation reduction. Climate change or rainfall reduction due to global warming (“*Duumamar yanayi*”- Hausa language phrase, for global warming, as mentioned by the respondents), is the least influential factor for deforestation in the study area according to the respondents. Only less than 3% of the respondents reported “*Duumamar yanayi*” as a factor responsible for vegetation reduction in the area despite the prolonged widely circulated media awareness campaigns in the country. The low response rate of global warming suggests two possibilities; either, there was a limited influence of the climatic factors affecting vegetation change in the study area (chapter 4: 4.2.2), or; the respondents recognise the visible act (anthropogenic) of deforestation as the most influential factor in the area. The latter can be supported by the high percentage of responses for the cause of deforestation, which lean towards anthropogenic factors. In a broad sense, it is obvious from the responses that the combined effect of the anthropogenic factors (fuelwood demand, population increase, poverty and lack of other alternative sources of energy), jointly accounted for 73% of the reasons for deforestation in the area.

10.3. Ways of Reducing the Effect of Deforestation

Responses to the possible measures for combating deforestation (question 23 in appendix 1), are illustrated in figure 10.2.

From the figure, about 94% of the respondents answered the question, out of who, about 35% pointed afforestation as the best way of combating deforestation. The respondents revealed their responses in the following ways: “*planting of more trees after cutting the existing ones is very important*”; “*encouraging the replacement of trees and discouraging people from cutting them*”. One important response that summarised them all, and even added some suggestions was provided by respondent number 89, who mentioned that:

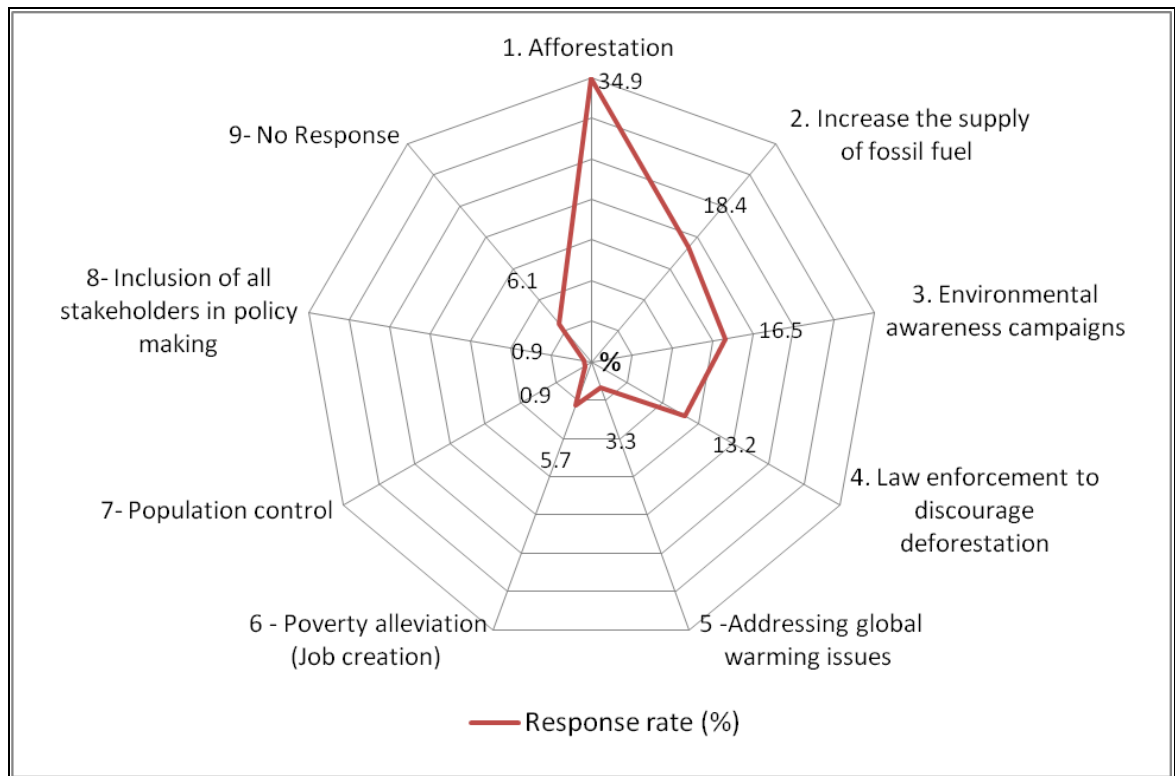


Figure 10.2: Measures to Combat Vegetation Changes in the Study Area

“planting of more trees in the farms will give farmers a sense of ownership. The farmers and the fuelwood suppliers should also be encouraged to practice a selective method of cutting the trees, which will assist them to monitor the progress of their tree resources”. This is a very good suggestion, which was also stated by respondent number two among the commercial fuelwood vendors.

According to 18% of the respondents, the increase in the supply of fossil fuel will reduce deforestation. Such responses, include among others, the following: 1) *“government should try to stabilise the provision of other alternative sources of energy (electricity, fossil fuels and coal) at an affordable price, which will encourage people to stop using fuelwood”*; 2) *“government should make alternative energy available, in order to reduce the over dependence on fuelwood”*.

Environmental awareness campaigns and effective law enforcement of the existing forest resources that will protect them from deforestation, accounted for about 16% and 13% of the total responses respectively. Jointly, they accounted for about 30% of the total response rate, which is high enough to indicate the perception of a much needed effort from the policy makers to intervene. The responses relating to environmental awareness were highlighted in the following ways: 1) *“people should be encouraged to plant more trees”*; 2) *“government should put more emphasis on its tree planting campaign*

awareness through media and other sources, which will encourage people to plant more trees...". On the other hand, the responses on the law enforcement was mentioned in the following way; *"government should enforce laws that will discourage the cutting down of trees, and encourage planting of more trees where necessary..."*.

Poverty reduction and job creation were identified by about 6% of the respondents as ways of reducing deforestation. Poverty alleviation was emphasised in the following way: *"government should provide more job opportunities for people in the country, in order to improve their purchasing power of the alternative energy sources"*.

Combatting global warming was reported by about 3% of the population as an important way of reducing deforestation. However, it was not clear what exactly the respondents are referring to here, given the topic is very complex. Nevertheless, they have indicated their understanding of the topic, which means that there was knowledge of the topic in Nigeria (even among the local people). The factors with the lowest influence in combating deforestation according to the respondents are population control and inclusion of all stakeholders in the policy decision making, each accounting for about 1% of the total responses. The inclusion of all stakeholders in the policy decision making was related in the following way: *"government should include the fuelwood vendors in any forest policy decision making and desertification awareness campaigns"*- respondent 69. The revelation of population control and inclusion of all stakeholders in the policy decision making as the lowest factors in deforestation control came as a surprise, given that they are both important factors of deforestation as observed in chapters 4, 8 and 9.

10.4. Discussion of Results

The overall results have indicted the government for failing to provide the basic requirements of its people. For example, six out of the eight reasons for the causes of deforestation were directly attributed to the lack of commitment by the government, while, all the measures for combating it were allocated to the government. This is a typical situation in Nigeria where there is high expectation from the government by the people, even at a time, when the government is complaining of its incapacity of coping with the existing burden. As such, providing solutions by the government alone, as demanded by the people, is unrealistic in the near future, because of the wide range of challenges, which the government is already facing (deterioration of basic social

infrastructure and the present insecurity). These are further discussed in the subsequent sections.

10.4.1. Reducing the Effect of Deforestation: What is the Current Situation?

10.4.1.1. Afforestation Programmes in Nigeria

Although, some of the past Nigerian government's policies have supported deforestation (refer to chapter 4: 4.2.3); the government also has in place policies that are aimed at improving the forest reserves and the restoration of forest areas in the country. Such policies as reported in chapter 2: 2.2.0-2.2.1.1 and emphasised in chapter 4: 4.2.3, include among others, the government support for afforestation programme since the 1970s. The assistance from the FG (through what is today known as the ecological fund - see chapter 6: 6.5.3), was provided directly to the states, who then allocate them to the local governments (depending on their requirement - see chapter 2:2.2.1.1). This assistance has not been managed properly. For example, Odihi (2003) noted that despite the huge investment in afforestation programmes by the government, particularly in the arid zone of the north (where the government distribute free seedlings), people do not cooperate, which leads to seedlings being over-grown into forest-like environment in the majority of the forestry department offices (where the seedlings are raised). However, it should be noted that government afforestation programmes in Nigeria (see chapter 4.4.3.2) were primarily aimed at reducing the effect of desertification in the arid north, and are therefore not for fuelwood acquisition. In this sense therefore, while the natural woodlands are being collected for fuelwood in the wild, no attention is being paid to replace them by the fuelwood collectors or the government. This is part of the reasons, why for example, in the Potiskum area, fuelwood collection has reached the worst state, where the collectors resort to the uprooting of dead tree stumps in *Burai* forest, because there was no replacement strategy after the primary deforestation was carried out (see chapter 9: 9.3.1.1).

Again, the performance of the Nigerian government's afforestation programmes (popularly called tree planting campaigns) is inadequate because there is no recourse to periodic checks of the aftermath, in order to assess the success or failure of the programme (Odihi, 2003). This has resulted in the failure of most afforestation programmes in the country (Odihi, 2003). This study has also argued that part of the failure of the tree planting campaigns in Nigeria, is due to the lack of continuity in the

government's agenda (see chapter 4: 4.2.3); which was again, the product of corruption (see chapter 6:6.5.3.2) and instability in the country's leadership.

The long term solution to the problem of deforestation in Nigeria, as indicated by the findings of this chapter, which also concurred with the findings of many researchers, is the accessibility of people to modern cooking fuels. This again was fully discussed in chapter 6, which concludes that there was no likelihood of that occurring in the foreseeable future. Even if it does, it was argued by Matsika et al. (in press) that its availability does not necessarily promote its usage, especially when poverty is obvious among the majority of the population (Eroke, 2012).

10.4.1.2. Local Efforts in Mitigating the Impact of Deforestation and Fuelwood Supply

It should be understood that the daily acquisition of fuelwood carried out in the majority of Northern Nigeria, combined with the scarcity of fossil fuels requires an urgent solution. While there are various ways of finding a long term solution to the problem, one possible way to reduce this hardship is through effective afforestation (Cardoso et al., in press). An effective afforestation programme that will target the people (not government ceremonies), by using rapidly growing species, such as the neem trees (that is very popular and accepted in the north- see chapter 8: 8.3.3.2), should be emphasised.

The provision of access of the common forest (lands)³² to the fuelwood collectors, has been argued by researchers in recent times (Arnold et al., 2006; Webb & Dhakal, 2011 & Cardoso et al., in press) as a possible short term solution because it is expected that they would be more conscious of the environment as well as of their activities once they understand that they own the forest. This is also promoted in this study (see figure 10.3 below for more detail) as a possibility for the continued sustaining of fuelwood supply. For example, Webb and Dhakal (2011) noted that the over exploitation of forest resources in Nepal has resulted to the mass return of the production of fuelwood on private lands (rain-fed agricultural land locally called "*Bari*"). Through this way, most families were able to cater for up to 80% of their fuelwood requirements in Nepal. Although, poorer households (landless) are still putting pressure on the common forest land, Webb and Dhakal (2011, p.131) assert that the extension of the private fuelwood

³² All land in Nigeria including its resources belongs to the government and one can only obtain it through lease from the government – see appendix 4 for more detail.

planting by large *Bari* landholders will possibly reduce such pressures on the common forest, because it can eventually promote greater fuelwood availability in the natural forests for *Bari*-poor and landless households. Therefore, Webb and Dhakal recommend the full support of a community forestry programme that would increase the equity of fuelwood allocation among the community by emphasising free access for *Bari*-poor families, landless and vulnerable households to the use of the natural forest.

Arnold et al. (2006) in their documentation of the various stages of fuelwood issues and their possible solutions since 1970s disagree with the views of this study and Webb and Dhakal (2011), on forest private ownership as the possible solution to deforestation issues. Arnold et al. partially emphasised the inappropriateness for interventions in the fuelwood situation because according to them it would possibly deviate forestry services to the provision of fuelwood. However, Arnold et al. (2006, p. 596) fully supports the view that *“declining access to fuelwood supplies or markets can raise significant problems in some areas, and for particular categories of users (poor families)”*. These contradictions have been raised in chapters 4, 8 and 9, where the author argued that the identification of deforestation issues (due to fuelwood collection), requires a thorough local study, and not just be based on over-generalization (Hassan et al., 2009; Webb & Dhakal, 2011 & Cardoso et al., in press). For example, the findings of chapters 6 and 9 have clearly shown how some parts of the country are vulnerable in terms of the future sustainability of fuelwood supply, which is widely used by the people, including the rich. Interestingly, certain areas of the country have started recognising these impacts, which is why for example, the fuelwood acquisition strategies using tree ownership, among some families in Nangere town emerged (see chapter 8: 8.3.1 & 8.3.3.2). This new development in Nangere, which also coincided with the findings of Webb and Dhakal (2011) in Nepal, is emphasised in this study, as an important strategy for a short term solution to fuelwood scarcity.

As highlighted earlier, this study also proposed a model of short term solution to the problem of fuelwood collection and deforestation in Northern Nigeria which is presented in figure 10.3 below. The proposal suggests that all stakeholders (including fuelwood vendors) should be integrated in the process of forest management as against the existing management strategy where government is solely responsible for the administration and management of the forest resources (refer to chapter 2: 2.2.1.1 for detail), while the

fuelwood vendors are considered as being part of the problem, and are therefore not integrated in the government decision making process.

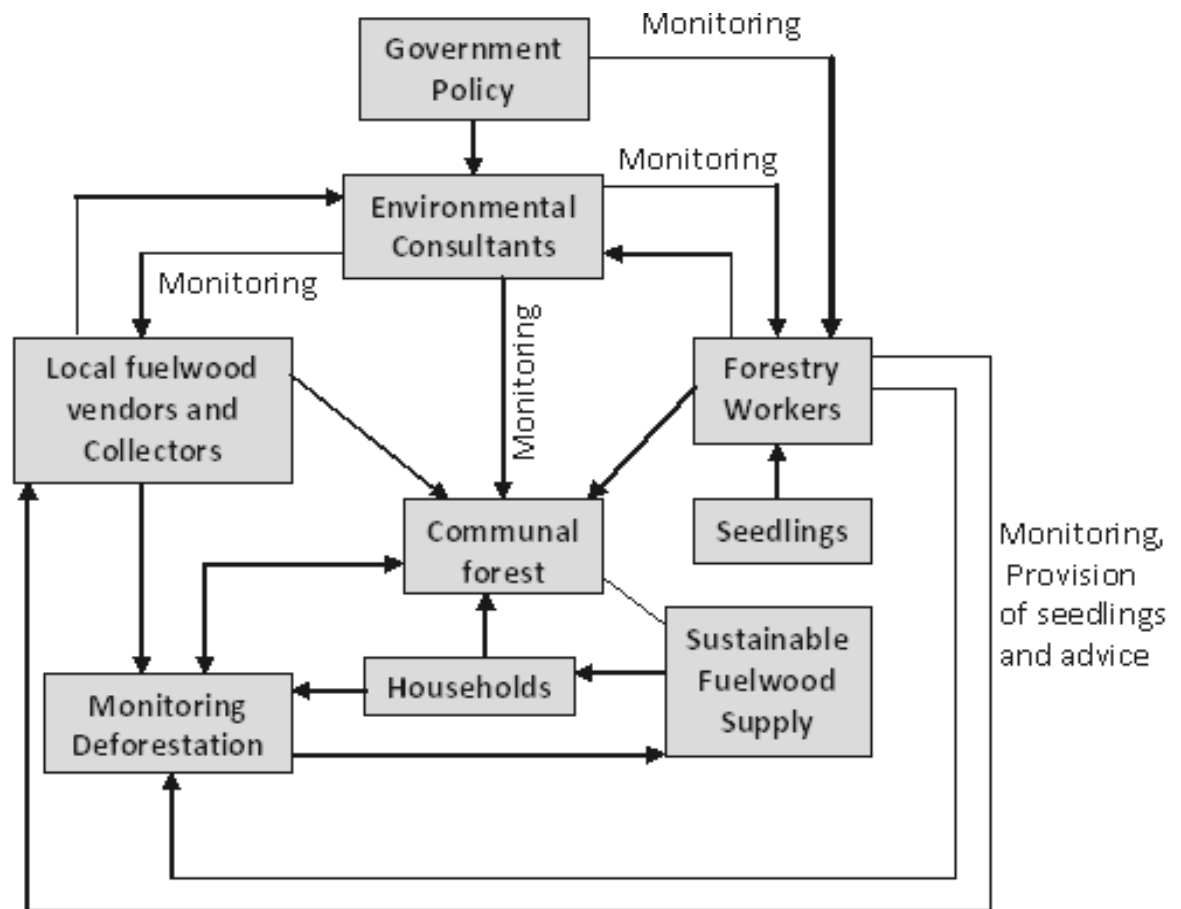


Figure 10.3: A Schema of Stakeholder Involvement in Monitoring Deforestation (Proposed Project)

Figure 10.3 shows the level of interaction between the stakeholders involved in the proposed project with the arrows linking the various participatory approaches between them. From the figure, the project suggests that the government (policy makers) should invite private sector (environmental consultants) to enforce the management policy of the forest resources while the local fuelwood vendors should be allowed to perform their operations legitimately (there would be allocated areas of the forest to be controlled and manage by the vendors through short term contract agreement). The consultants should be directly answerable to the government while the forestry workers (who are also government officials) and the fuelwood vendors should work closely with the consultants in terms of information sharing. The forestry workers would continue with their usual supply of seedlings as indicated by the arrow, however, priority would be given to the vendors who would collect and replace any damaged tree in the forest area allocated to them (by planting the new seedlings). The performance of the vendors would also be closely monitored by the consultants, forestry workers and the households (the

community would also be part of the stakeholders as regulators). Overall, various observers would be in charge of confirming whether the seedlings have been planted or not as against the conventional use of only one actor (the forestry workers). Using this kind of approach could improve the way vendors perform their activities in the forest in a sustainable way while maintaining the fuelwood supply to households. It should be noted that all the vendors interviewed (chapter 9) show some kind of dissatisfaction with the present forestry decision making process, indicating that they are not involved at any stage of the process. It is therefore assumed that this project will improve the situation because of their (vendors) direct involvement in monitoring deforestation as well as planting seedlings that could be used by later generations. This could also avoid a recurrence of what is happening in *Burai* forest where the vendors have to scavenge on the remains of dead stump trees that were destroyed earlier (see chapter 9: 9.3.1.1).

It can be observed from the proposition that the project's success lies with the various stakeholders' cooperation in monitoring the communal forest. However, the government's burden is reduced in the project, because of the involvement of all stakeholders while the provision of the free seedlings to the fuelwood vendors (to replace deforested areas) by the government, through the forestry workers, will serve as a regulatory facility to monitor the performance and success of the exercise.

This idea, when logically implemented would not only assist in alleviating the unnecessary pressure on the forest resources through dubious ways (bribes) - (see chapter 9: 9.2.8 & 9.4.2), but would also serve as an effective government management strategy to monitor the local vegetation changes. Another importance of the proposed project is that it can serve as a regulatory avenue to curtail some of the forestry official's bribery allegations (see chapter 9), because of the integration of environmental consultants in managing the project, who are to be paid directly by the government based on target achievement using the ecological fund allocated to the various state governments to address environmental problems (see chapter 6: 6.5.3.2).

Overall, it should be noted that the concept of "forest ownership" (by the fuelwood suppliers) advocated in this study is not a new strategy in the country. As taking aboard the history of forestry administration and land tenure laws in Nigeria (refer to chapter 2: 2.2.1 & appendix 4), it is obvious that prior to 1970s, the local communities were incorporated in the forestry management schemes in Nigeria, which was considered

effective in maintaining the standard of the communal use of their forest resources (FAO, 2003 & FAO, 2010b).

Note that a major problem that the proposed project overlooked or exaggerated is the issue of trust, where the proposal assumed that all the stakeholders will be sincere in the conduct of their allocated share of the task during the conduct of the exercise. Another concern that could possibly arise is the destruction of the seedlings by the nomads (grazing land use) after the vendors must have planted them in the forest. This kind of land use was observed during my visits to *Burai* forest on 27th July, 2010 and *Wawa* forest on 12th October, 2010, where cattle were observed to be wandering in the forest (refer to chapter 9.9.3.1.1). Although the latter problem can be avoided through the provision of improved seedlings that are unpalatable to the cattle (e.g. Neem tree), the former requires a change of attitude which depends on individual character and personality.

10.4.1.3. Employment and Poverty Reduction

Both unemployment and poverty reduction were reported by the respondents as the two sides of the same coin in relation to the cause and mitigation of deforestation in the arid north of Nigeria. While the massive unemployment observed today in Nigeria (see chapter 6: 6.5.3.1) was among the factors that results in deforestation (see chapter 9: 9.2.3 & 9.3.2), the reduction of unemployment and poverty alleviation, can improve the purchasing capabilities of fossil fuels for most families (see 8: 8.3.2.2). It should be noted that the Nigerian government has in place a National Poverty Alleviation Programme (NAPEP) and a National Directorate of Employment (NDE) (the two were merged in July, 2013), to regulate poverty and create more employment opportunities in the country. However, it was argued that despite the existence and commitment of such institutions, all attempts to address the situation in Nigeria over the past decades have not yielded much impact; while conditions have continued to worsen despite the resource potential in the country (Yakubu & Abbass, 2012). Most scholars attributed it to the resource curse theory³³ (James & Aadland, 2011 & Idemudia, 2012) that is systematically linked to

³³ Nigeria's economy has changed from that of agricultural base to oil dependency since the 1970s oil boom. The resource curse theory suggests that developing countries that are endowed with natural resources tend to underperform economically relative to their resource-poor counterparts (Idemudia, 2012). While the topic is still under debate among researchers about the causes of such curse despite the presence of resources that should positively be used to better the living conditions of the inhabitants, a consensus seems to exist now, which suggests that it is not just the presence of natural resources that leads to the resource curse (Bulte & Brunnschweiler, 2008). However, conditions such as the political structure

corruption, political instability and insincerity from the government officials (Agba et al., 2012b; Idemudia, 2012; NAN, 2012c & Nda-Isaiah, 2012). For example, it was argued that the agricultural sector in the country has faced prolonged periods of lack of meaningful government support (particularly the issue of sourcing affordable fertiliser to the farmers) which was argued to have impacted many agricultural families in the north (BBC Hausa, 2013 & chapter 6: 6.5.3.1).

It was therefore, recommended that policy makers should particularly look into the issue of fuelwood supply and appreciates the employment potential the sector is generating (chapter 6). However, it should be noted that emphasis on the employment potential of the fuelwood vending sector does not mean encouraging deforestation, but rather control its prevalence, through a systematic management approach. This study expects that by incorporating the recommendations of section 10.4.1.2 into the policy decision making; and legalising the activities of the fuelwood collectors (because it is unavoidable); through close monitoring of their actions (strict legislations and provision of improved seedlings whenever required), deforestation can be effectively reduced into a more regular pattern, that can be easily contained. Even though this proposal is so weak in principle, it can be a starting point for a comprehensive approach that will involve all stakeholders in the monitoring of their local forest resources. This could assist in reducing the over dependence on the government, whose afforestation programme was reported by the fuelwood vendors as inadequate (refer to section 10.4.1.1).

10.4.1.4. Population and Agriculture (Grazing Lands & Some of its Associated Conflicts)

The discussion of population in relation to deforestation was highlighted in chapter 4: 4.2.1. Although scholars have warned that the demographic impacts of deforestation must be cautiously interpreted, since population densities are not evenly distributed. It should however, be noted that population increase has been attributed by FAO to be the cause of about 50% of the entire developing world's deforestation (Motel et al., 2009). Nigeria's population of about 160 million, which is reported to have an annual natural increase rate of about 45 per 1000 (NBS, 2009), must have affected its rate of deforestation. It should be noted that only 16.3% of the respondents reported

and institutions around the extraction, processing and management of the generated revenues were argued to be the determinants of natural resources curse (James & Aadland, 2011).

overpopulation as the cause of deforestation in the study area (section 10.2, figure 10.1). A possible reason for the low response compared to FAO's figure could be due to the focus of the household research interview on "fuelwood", which is why fuelwood collection was rated as the highest (40%) cause of deforestation compared to the other factors identified by the respondents. However, the 40% of the respondents that rated fuelwood demand as the main factor of deforestation concurred with FAO's (2010a) findings as to the major cause of deforestation in Nigeria (see chapter 2:2.2.2). Therefore, the population's demand for food, through the acquisition of agricultural lands and energy in the DC is regarded as the greatest cause of deforestation (see chapter 2: 2.2.2.1; Odihi, 2003; Hassan et al., 2009; PRB, 2009 & Matsika et al., in press). The question now is how are the agricultural activities being practised?

Some of the issues of agricultural practices in Nigeria, which still remains subsistence in nature for the majority of the population, were highlighted in chapter 6: 6.5.3.1. The north, which receives a three to six months rainy season; depending on location, practices both rainfed and irrigated types of farming. It is considered as the dominant supplier of cereal crops, vegetables and animals (cattle) in the country (Odihi, 2003). The south, because of its abundant rainfall (7 to 10 months, depending on the location), practice tree crop farming, while both the two regions, practice root crop farming. Since in economic terms more food production is presumably undertaken to generate profits, which can be achieved by forest conversion into agricultural land uses (Motel et al., 2009, p.688), it can be argued that the geographical distribution of agricultural production in Nigeria places the north in a situation where it would have a higher deforestation rate than the south, because of the external pressure to produce more food for the country's growing population (Odihi, 2003). This can be illustrated by the policies introduced in Nigeria that favoured deforestation through agricultural land expansion (see chapter 4: 4.2.3).

Another agricultural practice that favoured deforestation as reported by the respondents is overgrazing. Again, this is a common problem particularly in Northern Nigeria, where cattle are reared in abundance. Part of the problem was highlighted in chapter 9: 9.2.4. It should however be noted that the issue of grazing land in Nigeria, has now attained a national status (BBC Hausa, 2012c & Onimisi, 2012). Although it is not the intent of this study to discuss the issue further, part of the problem is presented in box 10.1 for clarification.

Box 10.1: Views on Nomads/ Farmers Conflict in Nigeria

This is an annual conflict between the Fulani herders and the farmers (in the north and most recently in the southern part of Nigeria). The problem, was initially seen as a common problem in the north, where the majority of the herders dwell; but in recent times, (because of the Fulani's annual migration strategy, in search of a better pasture for their cattle), it is a reoccurring problem in every part of the country (most of the time leading to deaths and casualties; due to the use of heavy weapons during the conflict- Odoh & Chigozie, 2012, p. 113).

Report findings of clashes between the Fulani and the farmers attribute the cause of the conflict to the regular invasion of farmlands by the Fulani's (cattle) while on their annual migration (Odoh & Chigozie, 2012, p. 113). While this was always the case, the Fulani, which were at fault after any clash, alleged the farmers of invading their government allocated grazing lands and annual migratory routes (locally called "Burtali") (BBC Hausa, 2012c). These allocated grazing lands were well contained in the national master plan, even before independence, but were barely looked into to avoid future conflicts. It is obvious that the existence of such grazing lands have been reduced to a minimal level, to the extent that it is even difficult to ascertain their original locations in most areas, due to the invasion by the farmers (Odoh & Chigozie, 2012). This was always overlooked by the authorities during the conflicts. Below are some facts on this issue.

Nomads' viewpoint: Reason for the conflict

Speaking to IRIN, Hame Saidu, a pastoralist from Wase District of neighbouring Plateau state said, *"Every time there is [a] clash between nomads and farmers we nomads are labelled the aggressors. Nobody cares to look at the problem dispassionately and apportion blame fairly.....Our herd is our life because to every nomad life is worthless without his cattle. What do you expect from us when our source of existence is threatened? The encroachment of grazing fields and routes by farmers is a call to war... Wherever we turn we find the land reserved for our cattle to feast, taken over by farmers... It becomes difficult for our herd to move and graze without veering into crop fields... Once that happens, the farmers confront us and we have no option but to fight back"* - (IRIN news service, 2013).

Government's view point: Grazing reserves, routes

speaking to IRIN, Junaidu Maina, the director of livestock and pest control in the Nigerian Federal Ministry of Agriculture and Water Resources said, *"Nigeria officially has 415 grazing reserves but only one-third are in use; the remaining 270 have been built on or farmedThe government is carving out a grazing route to run through the central states of Nasarawa, Benue and Plateau, as well as Ebonyi in the south, according to Patrick Boga, an adviser in the ministry's livestock department.In September 2009 the government also started to mark out grazing reserves across northern Nigeria's Katsina and Bauchi states as well as the nearby capital, Abuja, to curb clashes.....The three planned reserves, to serve about 15 million pastoralists, will mean demarcating 175,000 hectares of grazing land, building veterinary service centres, and constructing settlements for nomads to use en route, at a cost of US\$247 million.....The government is also demarcating a 1,400km livestock route from Sokoto state in the northwest, to Oyo State in the southwest; and another 2,000km route from Adamawa state in the northeast to Calabar in the Southern delta region"*.

Source: IRIN news service (2013).

10.4.2. Way Forward

10.4.2.1. Stoves that Could Improve the Use of Fuelwood

Although this study does not look at the various ways of cooking among households from existing literature, it has discussed the impact of using improved wood stoves, with a

firmed assumption that its usage will decrease vegetation degeneration. The ways of finding a solution to the fuelwood problem started when the problem was first reported.

Part of the early suggestions for the solution was to either, increase the supply of fuelwood; or to reduce its demand (Gill, 1985). However, as reported above, the former suggestion is unrealistic in the short term in the arid north of Nigeria for various reasons highlighted earlier in this chapter. Therefore, in support of the latter contention as the possible solution, researchers have argued that the only realistic short term fuelwood demand reduction strategy was to promote the use of improved cooking stoves among families of the affected areas (Gill, 1985; Zein-Elabdin, 1997; Troncoso et al., 2007 & Jan, 2012).

The early wood stoves programme was promoted as being both fuel efficient and smokeless (Gill, 1985). The stoves were constructed from mud (unfired clay), and, were therefore not generally considered to be portable and simple to use (Gill, 1985). Gill argued that in practice, the improved stoves were not always more efficient, neither were they always smokeless than the traditional wood stove designs. As such, he considered them (at that time) to be a failure, because of their inability to address the issue of reducing fuelwood demand. Additionally, Zein-Elabdin's (1997) study of the improved wood stove situation in Sudan, reported that their impact on reducing deforestation was difficult to determine, because of the limited information surrounding their use. However, he noted that when they are widely used by the people, they may potentially reduce fuelwood consumption among families, which may have some impact on reducing deforestation.

Another observation is on the way wood stoves are being used. For example, Troncoso et al. (2007, p. 2804) reported that about 81% of the wood stoves users in rural Mexico have indicated a significant reduction of smoke, whereas the remaining 19% did not observe any obvious difference of smoke compared with their usual open fire stoves. In comparison with fuelwood savings, before and after the improved stove programme, they noted that the percentage of users was evenly divided (positive and negative) in terms of fuelwood saving benefits through using improved stoves. This could be the reason why the stove programme was not considered to be a better way of reducing deforestation, particularly because of the low take-up of the programme among the families (Jan, 2012), despite being in place for several decades. However, it should be

noted that the various interventions and emphasis on the use of wood stoves by the NGO's, was mostly in relation to health issues (smoke reduction), rather than curtailing deforestation.

Overall, a critical evaluation of the wood stove programme in DC, for example, suggests that the programme failed largely because it lacked proper awareness among the intended users. This was particularly in relation to the cost implication of obtaining it, and failure of the programme to demonstrate how the use of stoves can reduce the demand for fuelwood. Instead, the programme was more limited to discussion on some technical aspects of the design and diffusion strategies, rather than the important issue of their effect on the demand for fuelwood (Gill, 1985 & Jan, 2012, p. 3204).

10.4.2.2. Deforestation Awareness Campaigns

Some of the recommendations for curtailing deforestation (see figure 10.2) are given emphasis in awareness campaigns. It is common that the adoption of a new innovation will require many successive attempts in order to be able to permeate people's thinking (Troncoso et al., 2007). This can be illustrated from the failure to the success of adopting improved stoves in many DC (see section 10.4.2.2). In relation to deforestation, there are various awareness campaigns in place, through the local and international media, on the dangers of deforestation in Nigeria, particularly the northern part, which was reported to be losing about 10km of its landmass annually to desertification (scientifically unconfirmed speculations - refer to chapter 8: 8.3.3.3 for more detail). Hence the reason why over 16 percent of the respondents directly emphasise environmental awareness campaigns as part of the solutions to deforestation in the country.

Obviously, educating the society on the effect of deforestation is likely to reduce deforestation if the economic status of the target population is improved (see section 10.3, figure 10.2). This was earlier noted by Dolisca et al. (2007, p. 278) where they mentioned that *"there is nothing wrong with educational approaches to enhance societies' understanding of the value of preserving their forests, but such actions in many DC have failed in their results...."*. Therefore, awareness campaign programmes are themselves not a means to an end in relation to tackling deforestation. However, it may be regarded as a necessary condition for behavioural change (Dolisca et al., 2007).

10.5. Chapter Critique and Conclusion

10.5.1. Chapter Critique

The wide income gap that exists between the rich and the poor, or the government officials and the poor in Nigeria, is so huge, that innovation by the government is considered as a money making venture by the people. Therefore, it will not be a surprise, that the community or stakeholder's forest ownership model proposed in this study, if implemented, might be hijacked by some influential people (who may not necessarily be part of the fuelwood business), who might take advantage of the programme to make money. This can be illustrated by the 2012 national assembly's "fuel subsidy scam" enquiry, where companies owned by some influential people in the country (some are not even registered as oil companies) were indicted for claiming multiple payments from the government's fuel subsidy account on a single petroleum product they have imported into the country (Dada, 2012; Ogbonnikan, 2012; Ogunmola, 2012 & Okonjo-Iwela, 2012). Therefore, unless the government is serious about handling the proposed forest management approach, the programme may also likely fall prey to such individuals who will eventually sabotage the entire programme.

10.5.2. Conclusion

The ongoing dependency on fuelwood for cooking in Nigeria requires careful attention. The various approaches to the sustainability and continued supply of cooking fuel in Northern Nigeria are exhausted here, without a valid outcome. Programmes such as the success of investment in fuelwood energy conversion efficiencies (improved stoves), which was recommended by early researchers including Zein-Elabdin (1997), were assessed as having less impact in reducing deforestation. Like the reports of chapters 6 and 8, Zein-Elabdin (1997) and Festus (2012) agreed that only the promotion and accessibility of fuelwood substitutes may potentially reduce the problem of deforestation in the DC.

The inclusion of an afforestation programme in the acquisition of fuelwood is perceived as a possible way to reduce the pressure on wild native species (Júnior et al., 2011, p. 251). The proposed afforestation project of this chapter may also contribute to the local forest management in the affected communities (Cardoso et al., in press). Given that this approach was not new in Nigeria, it will only require some re-integration (into policy) and

a limited awareness campaign, since the fuelwood vendors have knowledge of their surrounding forest, and how the consequences of deforestation may affect their existence (refer to chapter 9).

In addition, the present work also suggests the need to encourage the appropriate inclusion of local stakeholders to support public policy that will promote greater self-sufficiency, which Cardoso et al., (in press, p.6), argued that in that way, *“the local dwellers would not only satisfy their basic needs, but could also utilize these avenues, to develop resilient practices which will help them take care of themselves, and their natural environments”*.

Even though a short term solution to the problem of deforestation has been proposed, the author also believe that the support for poverty alleviation would improve the situation by reducing deforestation as noted by Matsika et al. (in press). Matsika et al. argued that poverty has made some rural communities completely dependent on fuelwood in South Africa, in spite of the presence of a household electricity connection, at a subsidised price. They maintained that the communities prefer to invest their limited income in obtaining other basic family needs, rather than investing in the monthly tariffs of electricity. This clearly revealed the menace of poverty in aiding deforestation even with the benefit of having available options. Matsika et al. (in press, p.9), concluded that *“providing an alternative cooking fuel, like electricity in areas where household incomes cannot accommodate these additional costs will not immediately reduce the burden of the majority of these households to secure domestic energy services from the environment”*. Therefore, claims such as the potential for forest savings will be greater if fuelwood prices are directly related to the rate of deforestation (Zein-Elabdin, 1997), are baseless in this context, when the large majority of the population are in poverty.

It should also be noted that the apparatus of corruption in the majority of the DC like Nigeria does not guarantee the continuation of policies, neither do they guaranteed an effective poverty alleviation programmes, especially after a change in the government, which happens suddenly particularly in Nigeria (in the past). Therefore, based on the prevailing scenarios, it can be argued that the long-term sustainability of deforestation, especially in the majority of the impoverished DC is yet to be determined (Matsika et al., in press).

Chapter 11: Conclusions and Recommendations

11.0. Introduction

This chapter synthesises the empirical findings and conclusions that have emerged from the evaluation of the contribution of fuelwood consumption on the deforestation pattern in North Eastern Nigeria (NEN). The results of the chapters comprehensively fulfilled the aims and the objectives of the study by providing answers to the research questions originally posed (chapter 1: 1.1.2). For example, the results of chapter 4 highlighted the study area's vegetation change pattern from 1978 to 2005, while the results of the subsequent chapters demonstrated some of the social, economic and political (SEP) factors that are contributing to the regional (NEN) dependence on fuelwood.

This current chapter further summarises the achievements of the research findings and the impact that the result might have on policy makers. Recommendations are also provided and final thoughts of the research's limitation and its future direction are also highlighted.

11.1. Critical Reflection on the Research Questions

In order to achieve the aims and objectives of the research (chapter 1: 1.1), the researcher asked six questions, the responses to which have been discussed in chapters; 4, 6, 8, 9 and 10 of the study. A summary of these findings is as follows:

Research Question 1: What evidence is there of deforestation in the study area?

This question tries to identify whether the study area has experienced deforestation or not. The results of the Remote Sensing (RS) analysis conducted in chapter 4, which set out to investigate the vegetation change pattern of the study area from 1978 to 2005, using the techniques of RGB-NDVI, revealed that there is evidence of significant deforestation in the study area from 1978 to 2005. However, the pattern of vegetation change observed is far more complex and non-linear than had been expected prior to the analysis of imagery.

Research Question 2: What are the possible causes of deforestation in the study area?

This area of the research has provided some explanatory reasons to the potential causes for the vegetation change observed in the study area from the RS analysis. The discourse around the potential causes of deforestation has revealed a complex interaction of both

natural and anthropogenic factors as the reasons for the vegetation change observed. These reasons were discussed in the relevant chapters. For example, the conclusion of chapter 4 revealed that population increase, government policies, demand for farmland and the demand for fuelwood as the most important factors in the explanation of the vegetation changes in the study area. However, this study, like other researchers' findings (Odihi, 2003), concludes that fuelwood is the most important factor driving deforestation in the study area (chapters 6, 8, 9 & 10). Chapters 8 (results achieved using questionnaire surveys) and 6 (results achieved using the GIS exploration of the country's cooking fuel situation), have all concluded that the high cost and unreliability of modern cooking energy supply are the most effective factors, which attracts most of the households towards dependency on fuelwood in the study area and Northern Nigeria at large. This research supports the earlier work of Maconachie et al. (2009) who reported that most households in Kano are descending the energy ladder (use fuelwood) as a result of insufficient supply of modern energy in the region. Casse et al. (2004, p.35) also reported a similar situation in south western Madagascar, where they reported that fossil fuel price is a factor of the high fuelwood consumption in the region, which leads to deforestation.

The high rate of poverty and unemployment were also reported in chapters 9 and 10 (study conducted using questionnaires) and chapter 6, as factors responsible for deforestation (fuelwood collectors) in the northern region. This study therefore, concludes that unless solutions are found for alleviating poverty and creating job opportunities for the high levels of unemployed, the dependency on fuelwood is inevitable as illustrated by Matsika et al. (in press) in South Africa even if the supply of modern cooking fuel is eventually stabilised in the country.

Research Question 3: How is fuelwood being procured and distributed in the study area?

This question was discussed in a greater detail in chapter 9 of this study. The study concludes that there is an established fuelwood market in the study area, where manual labour and simple tools are used in the procurement and processing of fuelwood. This was contrary to the initial assumption of the researcher that power driven machines were also used. A report on the field observations of the two modes of fuelwood supply strategies (*Daba* and *Dandi*) and the market operations in chapter 9, confirmed the use of only simple tools, which were driven by manual labour throughout the operation. Chapter 9 also confirmed that there are seasonal variations in the activities of fuelwood vending.

The chapter concluded that both procurement and marketing (selling activities) of fuelwood are higher in the harmattan season than the rainy season (excellent for marketing, but poor for procurement) and a hot dry season (excellent for procurement, but poor for marketing). This was the reason, why the commercial vendors use the hot dry season to stock pile the woods for marketing in the rainy season, when procurement is poor due to inaccessibility of the roads leading to the collection centres.

The study, further noted that there were no consistent measurement standards (weight) in the selling of fuelwood among the vendors. The prices of fuelwood were observed to differ in terms of location, quantity of fuelwood and sometimes personal relationship of the buyer with the vendor. The most interesting thing about fuelwood selling as noted in chapter 9 was the flexibility of the market, which also serves the need of the poorest households in the supply chain.

In relation to procurement distance, chapter 4 has revealed the reduction of the study areas' surrounding vegetation, which has sharply declined since 1978. This is one of the reasons why the vendors sometimes have to travel up to a radius of 200km from Potiskum town (using different types of vehicles, depending on the mode of operation) in order to supply the fuelwood. This coincides with the suggestion of Leach (1987), who reported a lack of significant vegetation in the surroundings of most urban areas of the Developing Countries (DC). This study (like other previous researchers) also argued (chapter 9) that this was among the many reasons that lead to fuelwood vending. It should however be noted that even the business of fuelwood is not spared from the allegations of bribery and corruption in Nigeria. This was reported in chapter 9, as confirmed by the researcher, who was offered bribes by the vendors in one of the fuelwood collection centres, because they had mistaken the author for a forestry official and not a researcher, even though, both myself and my guide had previously explained why we were there. Bribery and corruption allegations as reported in chapters 9 and 10 are a typical issue in Nigeria that has caused the complete dilapidation of most government infrastructures and sectors in the country.

From the findings of chapter 9, the majority of the supply centres highlighted by the vendors were outside the administrative political boundaries of the study area. It is clear that most of these collection centres operated illegally. A typical example apart from the bribery allegations highlighted earlier, is noted by Odihi (2003), who reported that at one

of the collection areas (Buni Yadi forest - refer to chapter 9) local communities are reporting cases of armed men's presence in the forest at night, trying to collect fuelwood illegally. This suggests that fuelwood demand in the region have reached a critical point. Therefore, if the present fossil fuel supply situation remains the same, it will likely result in a further increase in dependence on the use of fuelwood among households in the north, leading to continued deforestation in the region's remaining scant forest zones.

Research Question 4: What is the relationship between fuelwood consumption and the availability and prices of petroleum products?

The discussions in chapters 6, 8, 9 and 10 have provided the answers to this question. For example, chapter 8 noted that whilst there was high interest among the households in using modern cooking fuels, the high cost and unreliability in its supply is a restricting factor. This was discussed in chapter 6: 6.5.2 which illustrates how allegedly internal politics, deliberate sabotage and smuggling within the fossil fuel distribution stakeholders is hampering the supply of the petroleum products to the northern part of the country. This was part of the reason (reported in chapter 10) why the households maintained that the government should try to stabilise the provision of other alternative sources of energy at an affordable price, in order to encourage people to use these. Various researchers have also discussed this as a potential issue that is causing the over dependence on fuelwood (Adelekan & Jerome, 2006 & Maconachie et al., 2009).

Chapter 6 illustrated (using maps) the relationship between fossil fuel distribution and the high dependency on fuelwood. The chapter concludes that the distribution of fossil fuel products in Nigeria does not favour the north, and speculates that the inter-regional disparity is a possible reason for the region's high dependence on fuelwood also. It was also reported that the withdrawal of fuel subsidy in the country is likely to trigger the situation in the disadvantaged north. An attempt to address the question as to why some states are insufficiently supplied with fossil fuel proved difficult to ascertain in this study.

Although family size (mostly extended family) and cultural values in the north (refer to chapter 8) are among the other factors noted for the use of fuelwood in the north, the results within this study conclude that there was evidence of a strong relationship between the price of petroleum products and the high dependence on fuelwood in the region. Because, as reported in chapter 6, the use of fossil fuel, for example bottled gas for cooking is seen by many people in Nigeria as a symbol of affluence (due to its high

cost), which is why it is only used by the higher income and wealthy families with a few household sizes.

Research Question 5: Does seasonal or protracted fuelwood scarcity have significant socio-economic effects on households?

The findings of chapter 8 indicate that the high demand and consumption of fuelwood in the study area is manifesting itself in the family's income, where the majority of them buy their fuelwood from the vendors; costing them up to 15% of their monthly income. Even the few households that fetched their fuelwood from the common forest, using family labour, have highlighted the increased distance in fetching the wood when compared to the last few decades. In relation to the choice of fuelwood type, the households have identified that their preferred fuelwood species are available in the market, but at higher prices, than the less preferred types.

The increased fetching distance has resulted in the invention of commercial fuelwood activities (refer to chapter 9). The commercial fuelwood activities were regarded by most researchers as the potential cause of the active deforestation in most semi arid zones of the Developing Countries (DC). However, as argued in chapter 9, the commercial fuelwood activities, provides employment to the poor people, who also engaged in the rainy season agriculture. The commercial fuelwood business has created a variety of jobs, which primarily require the physical ability of the worker. The business activity is highly organised in such a way that everyone knows what is expected of them.

Although, this study argues that improving the supply and accessibility of fossil fuel may relieve the vegetation from active deforestation, Matsika et al. (in press) have pointed out that unless the purchasing power of the people is improved, such expectations are likely to fail. Therefore, due to the high rates of unemployment in Nigeria, this study also concludes that (chapters 9 & 10), apart from the limited fossil fuel supply, the high unemployment and poverty rates in the northern region of the country (FAO,2010a), have a substantial impact on the region's dependency on fuelwood, which needs attention.

Research Question 6: Is there any government intervention in terms of actions/ policies to address the fuelwood situation especially with regards to avoiding environmental damage, and if so, are there any significant changes as a result of such policies?

This research question assesses the interventions of the local and national government in addressing the fuelwood situation in the country. Evidence from the various discourses of chapters 4, 6 and 8 have revealed that there were several government programmes to address some of the problems that lead to the over dependence on fuelwood. However, there was no evidence from the discourse of this study of any positive impact that the government policies have yielded in reducing the impact of fuelwood use. This is because fuelwood's relevance as the most reliable source of cooking energy among the majority of the households in the country lacks administrative recognition in terms of the hardship involved in its procurement (chapter 9). For example, results in chapters 4 and 10 have revealed that there is a Federal Government (FG) afforestation programme in the country, which began since 1976, in the name of Arid Zone Afforestation Project (AZAP) (FMEN, 2007). The programme was initiated to tackle the problems of desertification, through the establishment of woodlands, shelterbelts and windbreaks, which resulted in the raising of over 10 million seedlings annually between 1978 and 1984 and the creation of about 150 kilometres of shelterbelts (3,680 hectares of woodlands) (FMEN, 2007). However, due to corruption (refer to chapter 6: 6.5.3.2.) and lack of continuity of government policy especially whenever there is a change in government (refer to chapter 4: 4.2.3), the programme is perceived to be a failure in principle (BBC Hausa, 2007).

Even the FG's various fuel subsidies (electricity tariffs and fossil fuel) that were initiated to reduce the financial impact on its citizens have been partly withdrawn in January 2012 due to the abuse of the programme by some corrupt individuals (Isah, 2013). Similarly, the FG's poverty alleviation programme (chapter 10) in the country, has failed to provide any meaningful change to the massive number of unemployed citizens in the country (Yakubu & Abbass, 2012).

11.2. Reflecting Back on the Research Problem

The research problem (chapter 1: 1.3) has identified a serious issue regarding the vegetation decrease in the NEN, which is affecting the area's landscape. Two contrasting statements evolved from the literature, which were both assessed in this study using a mixed methodological approach. Even though, the result of this study has shown a clear indication of deforestation in the study area, the deforestation patterns observed were irregular, in such a way that there were periods of remarkable vegetation decrease as well as increase between 1978 and 2005. The results revealed that the vegetation of the

area was higher in 1987 compared to the other periods of investigation. Also, the vegetation of 2005 was slightly higher than 1999. This partially confirmed the claims of Anyambaa and Tucker (2005) and Olsson et al. (2005) whose research also like this study used RS modelling. Apart from these two periods (1987 & 2005), the remaining epochs that this current research considered, show a remarkable decrease of vegetation, which is why, the study concludes, that there was a substantial decrease in the vegetation of the study area, as earlier noted by Odihi (2003). Even though the deforestation in the region is often attributed to the collection of fuelwood, which this study also concurred, Bdiya's (1987) earlier claim that the area would be totally devoid of vegetation by 2000 due to fuelwood collection, was not supported in this study.

11.3. Limitations of the Research

The research's limitations have been described in the various chapter critiques' (4: 4.3.2; 6: 6.6.2; 9: 9.4.2 & 10: 10.5.1). However, the overall research has faced some issues, particularly the difficulty of executing the second field trip as scheduled due to the *Boko Haram* crisis (see chapter 6: 6.5.3.1) that afflicts the study area. This has significantly affected the initial scheduled planning and some of the methodological approaches of this study. However, local knowledge of the area by the author and the first field trip that lasted for about four months of intense field work (interviews, consultations with relevant authorities and field observations), has furnished the author with contacts in the area, which assisted in achieving most of the intended work that was scheduled in the cancelled second trip.

Also, the study was unable to provide any information from the government officials, the "*Udawa's*" (chapters 8, 9 & 10) and the "*Yan kungiya*" (chapter 9), who were alleged by the households and fuelwood vendors as playing some role in the management and execution of deforestation in the region. In this regard, the researcher attempted to contact the *Yan kungiya*, but this was without success. However, no attempt has been made to contact the *Udawa* (because they are seasonal herders) or the government officials to clarify on the allegation, because my personal experience during the field trip has confirmed the bribery allegations against the forestry workers (see chapter 9: 9.4.2 for detail).

The establishment and activities of the local community vigilante group "*Yan kungiya*" highlighted in chapter 9 needs further investigation. The inability to meet up with any of

them (after several attempts; because they operate in secret- see discussion in chapter 9: 9.2.4), to comment on their selfless community services, resulted in lack of further discussion about their activities in this study. It is believed that there is a need to consult them and integrate them into this study's proposed forest management scheme.

The activities of *Udawa* (highlighted in chapters 9 & 10) in the prevalent deforestation and conflicts with the farmers, are serious allegations, which require further investigation, due to the nature and scale of the problem in the country. Media reports (BBC Hausa, 2012c) have shown that the problems are annually recurrent. Further inquiries into these allegations (which are outside the remit of this study) will obtain more information than this study has been able to provide. It is felt that this study has achieved its objectives despite these limitations.

11.4. Key Achievements of the Research

- The study contributes to the existing knowledge of the factors responsible for deforestation. It has also contributed to the literatures of environmental geography, energy geography and human geography communities, in a wider perspective. The use of multiple methodologies adopted in this study to examine the problem from different perspectives within the same study area has not previously been undertaken. This approach enabled the researcher to analyse in greater detail the perceptions and concerns of fuelwood users and suppliers, after studying the deforestation process over a period of at least two and half decades using satellite imagery. The RGB-NDVI results for example, have empirically proved the complex nature of the vegetation change pattern of the study area which has never been reported or discussed in the past using a similar approach designed in this study.
- The integration of GIS in the study, has visually illustrated the north and south divides in the distribution of fossil fuels and fuelwood consumption patterns. This is also a new observation that was not identified in the literature reviewed in this study. Even though there is insufficient supply of modern cooking fuel in the entire country (with the north being affected most), this study has further confirmed that the high dependence on fuelwood in the north correlates with the shortage in the distribution, high cost (mostly obtained from the black market) and unreliability of modern cooking fuel supply to the region. This study also revealed that the high rate of unemployment and poverty in

Nigeria is likely to discourage people from using modern cooking fuel even if it is made available.

- The structural activities of the fuelwood vendors are comprehensively reported in this study which highlighted for the first time, how the two modes of fuelwood collection operations (*Daba* and *Dandi*- refer to chapter 9) are conducted. It also shows how fuelwood business is thriving due to the fuelwood scarcity, lack of supply of alternative energy, the massive unemployment and corruption in the country. For example, the marketing strategy of lending (chapter 9: 9.2.1.) is an effective way of integrating the housewives into the fuelwood vending circle (which personal observation of the study area has confirmed).
- Similarly, the successful application of Geographically Weighted Regression (GWR) model for the first time in this kind of study, has contributed to the visual representation of the social motivators of fuelwood usage among the various states of Nigeria, as against the conventional study approach of qualitative analysis.
- The research findings of the study have also indicated that there is a strong environmental awareness among the people of the study area, where some of them have already started to mediate the effects of deforestation by embarking on a tree ownership scheme in their farms (particularly in Nangere) to supplement their fuelwood needs.
- The *Almajiri*'s (small children) reported in chapter 8, as being part of the fuelwood supplying chain, is also an observation that was not reported in the literature consulted in this study. Similarly, hoarding as a strategy for fuelwood supply (chapter 9), was not covered extensively in the literature consulted in this study.

11.5. Policy Implication of the Results

Nigeria presents a unique problem in terms of fuelwood, because most northern parts of the country have already been declared as unsustainable due to the rapidly decreasing vegetation stocks. Therefore, with the very high demand of fuelwood among households in the north, consumption of fuelwood is rated as an important driver of deforestation in the region.

This study has revealed that the collection pattern of fuelwood has changed from that of traditional household collectors to organised traders and from the cleaning of dead wood

(sustainable) to the cutting down of live trees (unsustainable) to meet the demands. The relationship that exists between the fuelwood vendors and the forestry officials (“*cat-and-mouse game*”) requires an urgent intervention if the limited remains of the regions’ vegetation cover is to be safe. As this study has highlighted, commercial fuelwood vending is already presenting threats to the pockets of areas with dense vegetation in the region, in the form of cross border trading among the northern states. This is definitely a cause for concern, especially in a region where some of its states are already threatened by desertification.

Part of the solution proposed by this study after due consultation of the relevant literature, is for the government to improve on its shortfall of supply of other forms of cooking energy in the region, which will relieve the pressure on the forest. However, evidence from community case studies in the places which have enough modern cooking fuel supply in the DC (Matsika et al., in press & Wilson et al., 2012) suggests that improving the standard of living (job creation and poverty alleviation) is the best strategy. This is because an abundant supply of alternative energy does not automatically negate the use of fuelwood, in an already poverty stricken society (Matsika et al., in press). Therefore, it is also the suggestion of this study that the government policies on poverty alleviation programmes and job creation should be prioritised and rationally executed, even if the government is to improve the supply of the alternative cooking fuels.

Although there are existing laws enacted in order to discourage deforestation in Nigeria (see chapter 4 & appendix 5), little has been achieved to stop this practice, which can be attributed to lack of awareness of the importance of fuelwood to the rural economy. In this sense therefore, the authorities do not seem to be fully aware of the socio-economic implications of fuelwood vending with respect to job creation. It should be noted that this study is not advocating deforestation in favour of the employment opportunity in the fuelwood business, which is why suggestions have been made to the policy makers of how to effectively manage the remainder of the northern region’s vegetation. The proposed project model, will involve the entire stakeholders in the deforestation monitoring process (full explanation in chapter 10: 10.4.1.2). This can assist in overcoming the ambiguity of the existing forest monitoring approaches that is full of bribery allegations. The model, which is adopted from the Nigerian forestry management system prior to 1970 (see chapter 2: 2.2.1), will also provide a sense of ownership of the common

forest to its people. However, this model can only succeed if executed in a transparent manner, and with strict compliance with and recourse to the new conditions.

This research has generated a similar opinion to Arabatzis et al. (2012) that reiterated the need for adopting a management and planning approach that will take into account both the *“biophysical characteristics of the land and the social, economic, cultural and political status of the region..... in order to increase the production of fuelwood from both the agricultural and the forest land. This will also assist in creating new jobs in the rural areas, which could contribute to the development and the achievement of social and environmental sustainability at local, regional and national level”* (Arabatzis et al., 2012, p. 6495).

11.6. Final Thoughts and Future Directions

In summary, this study has shown that the management of deforestation relating to fuelwood consumption is inherently politicised in Nigeria, and efficient solutions to the problem have yet to be identified.

The results of chapter 4 have revealed a slight vegetation increase in both the periods 1984 to 1987 and 1999 to 2005. Possible answers have been sought to this pattern of irregularity observed from the analysed images. However, given that the analysis terminates in 2005, there is the possibility of extending the study in the future in order to determine if the vegetation will continue to show fluctuating tendencies towards increase or decrease, as observed in this thesis. Also, given that the Landsat images used in this analysis are freely available (upon request), from USGS, and that the Nigerian National Space Research and Development Agency (NARSDA) (Nigersat- 1 satellite images) have recently started supporting researchers with free satellite data, it will be possible to update the study in subsequent years, and/or consistently monitor the performance of the vegetation on an ongoing basis.

Overall, the research has shown a complex pattern in terms of the potential reasons for deforestation, and the findings are more robust because of the use of multiple methodologies at different scales. The research questions originally posed have been addressed and a range of new findings have contributed to the advancement of knowledge in this area of research.

Bibliography

- Abubakar, A. (2011). Senate confirms Diezani, Bala, Ruqayyatu. *Thisday Newspaper*, 30/06/ 2011 edition.
- Abuja Power Station (APS), (2010). Powering Your Electrical Demands. [Http://Www.Aps.Jehata.Com/Gencomp.Html#Section1](http://www.Aps.Jehata.Com/Gencomp.Html#Section1) – accessed 2/2/2011
- Adams, W. M. (2009). *Green Development: Environment and Sustainability in a developing world*. 3rd edition, Routledge, London.
- Ademiluyi, I.A., Okude,A.S., & Akanni,C.O. (2008). An appraisal of land use and landcover mapping in Nigeria. *African Journal of Agricultural Research*, 3(9): 581-586.
- Adedipe, N.O., Olawoye, J.E, Olarinde, E.S., & Okediran, A.Y. (1998). Rural communal tenure regimes and private landownership in western Nigeria. Land Reform Bulletin: Sustainable development department (SD), FAO. <http://www.fao.org/sd/ltldirect/LR972/w6728t13.htm> - accessed 2/2/2011.
- Adelekan, I.O. & Jerome, A.T. (2006). Dynamics of household energy consumption in a traditional African city, Ibadan. *Environmentalist*, 26: 99–110.
- Adenikinju, A. F. (2003). Electric infrastructure failures in Nigeria: a survey-based analysis of the costs and adjustment responses. *Energy Policy*, 31: 1519–1530.
- Adeoti, O., Idowu, D. O. O., & Falegan, T. (2001). Could fuelwood use contribute to household poverty in Nigeria? *Biomass & Bioenergy*, 21(3): 205-210.
- Adesina, F. A. (1990). Planted Fallows for Sustained Fuelwood Supply in the Humid Tropics. *Transactions of the Institute of British Geographers*, 15(3): 323-330.
- Agba, G., Gbadebo, B. & Idowu, B. (2012a). Transparency International 2012 Report: Togo, Niger, Mali less corrupt than Nigeria. *Leadership Newspaper*, 6/12/12 edition.
- Agba, G., Awom, U. & Ukaibe, C. (2012b). Christmas/New Year Celebrations: Jonathan seeks N161bn to avert fuel scarcity. *Leadership Newspaper*, 12/12/2012 edition.
- Agbetuyi, A.F., Akinbulire T.O, Abdulkareem A. & Awosope C.O.A. (2012). Wind Energy Potential in Nigeria. *International Electrical Engineering Journal*, 3(1): 595-601.
- Agbo, P. (2012). NUPENG begins indefinite strike. *Leadership Newspaper*, 27/07/2012 edition.
- Agresti, A. (2007). An introduction to categorical data analysis. 2nd ed. John Wiley Hoboken, N.J.
- Akarakiri, J. B. (1999). Private electric power generation as an alternative in Nigeria. *Energy*, 24: 445–447.
- Akinsola, O.D. & Oladele, O.I. (2004). National agricultural land development authority's (NALDA) intervention programme in Nigerian agriculture: Lessons and challenges. *Food, Agriculture & Environment*, 2 (1): 249-254.
- Akioye, S. (2013). Lagos - Ilorin train ride: cheap fare of pain and discomfort. *Leadership Newspaper*, 10/02/2013 edition.

- Ako, R.T. (2009). Nigeria's Land Use Act: An Anti-Thesis to Environmental Justice. *Journal of African Law*, 53(2): 289-304.
- Alabe, M. (1996). Household energy consumption patterns in Northern Nigeria. *Energy for Sustainable Development*. Vol II. No.5.
- Ali, J. & Benjaminsen, T. A. (2004). Fuelwood, timber and deforestation in the Himalayas - The case of Basho Valley, Baltistan Region, Pakistan. *Mountain Research and Development*, 24(4): 312-318.
- Alohan, J. (2011a). NUPENG uncovers fuel supply sabotage plot in North. *Leadership Newspaper*, 02/08/2011 edition.
- Alohan, J. (2011b). Kerosene scarcity: NNPC punctures IPMAN's lopsided allocation claim. *Leadership Newspaper*, 24/06/2011 edition.
- Alohan, J. (2011c). FG hikes electricity tariff. *Leadership Newspaper*, 24/06/2011 edition.
- Alli, Y. (2012). New revenue formula: RMAFC begins verification of indices in 36 states, FCT today. *The Nation Newspaper*, 30/04/2012 edition.
- Amacher, G. S., Hyde, W. F. & Joshee, B. R. (1993). Joint production and consumption in traditional households: Fuelwood and crop residues in two districts in Nepal. *The Journal of Development Studies*, 30 (1): 206-225.
- Amacher, G. S., Hyde, W. F. & Kanel K.R. (1996). Household fuelwood demand and supply in Nepal's tarai and mid-hills: Choice between cash outlays and labor opportunity. *World Development*, 24 (11): 1725-1736.
- Amacher, G. S., Hyde, W. F. & Kanel, K. R. (1999). Nepali fuelwood production and consumption: Regional and household distinctions, substitution and successful intervention. *Journal of Development Studies*, 35 (4): 138-163.
- Amacher, G. S., Koskela, E. & Ollikainen, M. (2009). Deforestation and land use under insecure property rights. *Environment and Development Economics*, 14: 281-303.
- Amatya, V. B., Chandrashekar, M. & Robinson, J.B. (1993). Residential sector energy-supply-demand Analysis - a modeling approach for Developing-Countries and fuelwood-supply sustainability in Nepal. *Energy*, 18(4): 341-354.
- Amnesty International, (2012). Nigeria: Trapped in the cycle of violence. Amnesty International Ltd, London.
- Amokeodo, T. & Isah, A. (2011) Census Crucial For Development – Tribunal Chairman. *Leadership Newspaper*, 01/07/2011 edition.
- Anozie, A. N., Bakare, A.R., Sonibare, J.A. & Oyeibisi, T.O. (2007). Evaluation of cooking energy cost, efficiency, impact on air pollution and policy in Nigeria. *Energy* 32: 1283–1290.
- Anthony-Uko, N. (2013). Afam, Kaduna Power Firms: Deadline For Fresh Bids Closes. *Leadership Newspaper*, 01/02/2013 edition.
- Anyambaa, A. & Tucker, C.J. (2005). Analysis of Sahelian vegetation dynamics using NOAA-AVHRR NDVI data from 1981–2003. *Journal of Arid Environments*, 63: 596–614.

- Apan, A. A. & Peterson, J.A. (1998). Probing tropical deforestation: The use of GIS and statistical analysis of georeferenced data. *Applied Geography*, 18 (2): 137–152.
- Arabatzi, G., Kitikidou, K., Tampakis, S. & Soutsas, K. (2012). The fuelwood consumption in a rural area of Greece. *Renewable and Sustainable Energy Reviews* 16: 6489–6496.
- ArcGIS 9, (2004). Geodatabase Workbook: Symbolizing Features. GIS by ESRI. USA.
<http://www.countyofdane.com/lis/PDF/Symbolizing.pdf> - accessed 10/2/2011
- Aregheore, E. M. (2009). Country Pasture/Forage Resource Profiles: Nigeria. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
<http://www.FAO.org/ag/AGP/AGPC/doc/Counprof/PDF%20files/Nigeria.pdf> - accessed 1/12/2012.
- Arnold, J.E.M., Kohlin, G. & Persson, R. (2006). Woodfuels, Livelihoods, and Policy Interventions: Changing Perspectives. *World Development*, 34 (3), 596–611.
 doi:10.1016/j.worlddev.2005.08.008
- Armstrong, M. R., Xiao N. & Bennett, D.A. (2003). Using Genetic Algorithms to Create Multicriteria class Intervals for Choropleth Maps. *Annals of the Association of American Geographers*. 93(3):95-623.
- Aroh, K.N., Ubong, I.U., Eze, C.L., Harry, I.M., Umo-Otong, J.C. & Gobo, A.E. (2010). Oil spill incidents and pipeline vandalization in Nigeria: Impact on public health and negation to attainment of Millennium development goal: the Ishiagu example. *Disaster Prevention and Management*, 19 (1): 70-87. <http://dx.doi.org/10.1108/09653561011022153>.
- Aron, J., Eherhard, A.A., & Gandar, M.V. (1991). Fuelwood deficits in rural South-Africa. *Biomass & Bioenergy*, 1(2): 89-98.
- Asuni, J. B. (2009), *Blood Oil in the Niger Delta, Special Report*, Washington DC: United States Institute for Peace.
- Ati, O.F., Stigter, C. J., Iguisi, E.O. & Afolayan, J.O. (2009). Profile of rainfall change and variability in the Northern Nigeria, 1953-2002. *Journal of Environmental and Earth Sciences*, 1(2): 58-63.
- Balouga, J. (2012). The Political Economy of Oil Subsidy in Nigeria. *International Association for Energy Economics, Second Quarter*, 31-35.
- Bart, J.M. (2005). Pre-water audit for the Komadugu-Yobe River Basin, Northern Nigeria and Southern Niger. (IUCN - The World Conservation Union, Federal Ministry of Water Resources and Nigerian Conservation Foundation, Kano, Nigeria). http://www.kyb-project.net/_products/200511-pre_water_audit_KYB.pdf - accessed 20/06/2010.
- Baxter, J. & Eyles, J. (1997). Evaluating qualitative research in social geography: establishing 'rigour' in interview analysis. *Transactions of the Institute of British Geographers*, 22 (4): 505-525.
- BBC Hausa, (2011 a). Hausa language service ("Shirin Safe" 30 minutes Radio news).
<http://www.bbc.co.uk/hausa/> - broadcasted on 24/07/11.
- BBC Hausa, (2011 b). Hausa language service ("Shirin Hantsi" 30 minutes Radio news).
<http://www.bbc.co.uk/hausa/> - broadcasted on 08/06/11
- BBC Hausa, (2012a), Hausa language service ("Shirin Rana" 30 minutes Radio news).
<http://www.bbc.co.uk/hausa/> - broadcasted on 21/10/ 2012

- BBC Hausa, (2012b), Hausa language service ("Shirin Dare" 30 minutes Radio news).
<http://www.bbc.co.uk/hausa/> - broadcasted on 11/06/12.
- BBC Hausa, (2012c), Hausa language service ("Shirin Rana" 30 minutes Radio news).
<http://www.bbc.co.uk/hausa/> - broadcasted in November, 2012.
- BBC Hausa, (2007), Hausa language service ("Shirin Rana" 30 minutes Radio news).
<http://www.bbc.co.uk/hausa/> - broadcasted on 17/06/2007.
- BBC Hausa, (2013), Hausa language service ("Ra'ayi Riga: Shirin rarraba wayoyin salulaga manoma a Najeriya" 1 hour Radio news and discussion). <http://www.bbc.co.uk/hausa/> - broadcasted on 11/01/ 2013.
- BBC Africa, (2012). Nigerian fuel subsidy: Strike suspended. BBC African News -16 January 2012.
<http://www.bbc.co.uk/news/world-africa-16579001> - accessed 10/01/13.
- BBC Africa, (2008). Child beggars of Nigeria's Koranic schools. BBC Africa - 23/12/ 2008.
<http://news.bbc.co.uk/1/hi/world/africa/7796109.stm> - accessed 22/04/2013.
- Bdliya, H. H. (1987). Fuelwood consumption: a constraint to rural development in Borno State. In Odihi, J. (2003). Deforestation in afforestation priority zone in Sudano-Sahelian Nigeria. *Applied Geography*, 23: 227–259.
- Bearer, S., Linderman, M., Huang, J., An, L., He, G. & Liu, J. (2008). Effects of fuelwood collection and timber harvesting on giant panda habitat use. *Biological Conservation*, 141(2): 385–393. <http://dx.doi.org/10.1016/j.biocon.2007.10.009>
- Bensel, T. (2008). Fuelwood, deforestation, and land degradation: 10 years of evidence from Cebu province, the Philippines. *Land Degradation & Development*, 19 (6), 587-605.
- Bernard, H.R. (2000). Social research methods: qualitative and quantitative research approaches. Sage, Thousand Oaks.
- Birol, F., Aleagha, A.V. & Ferroukhi, R. (1995). The economic impact of subsidy phase out in exporting developing countries: a case study of Algeria, Iran and Nigeria. *Energy policy*, 23 (3): 209-215.
- Bisalla, S. M. & Muhammad, H. (2012). Ribadu report: FG illegally siphoned N51bn from NNPC. *Dailytrust Newspaper*, 05 /11/2012 edition.
- Bitter, C., Mulligan, G. F. & Dall'erba, S. (2007). Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method. *Journal of Geographical Systems*, 9: 7–27.
- Blair-Rains, A., Allan, J. A., Heriberto Cuanalo de la C'Erda, Richards, P., Parry, D. , Gardner W. E., Hawker, B., O'Brien C. I. M. , Saffery & Trevett, W. (1979). *Mapping Nigeria's Vegetation from Radar: Discussion*. The Geographical Journal, 145 (2): 274-281.
- Blench, R. (2007). Hausa Names for Plants and Trees: Hausa plant names – Hausa-Latin. Circulation version [Draft -Prepared For Comments]. 2nd Edition.
<http://www.rogerblench.info/Ethnoscience/Plants/General/Hausa%20plant%20names.pdf> - accessed 10/1/2011.
- Borno State of Nigeria Gazette, (1987). Borno State Notice No. 62. No.34 Vol. 12. Government Printer, Maiduguri, Nigeria.

- Brew-Hammond, A. & Kemausuor, F. (2009). Energy for all in Africa—to be or not to be?! *Current Opinion in Environmental Sustainability*, 1:83–88.
- Brewer, C., Harrower, M. & The Pennsylvania State University, (2002). Colour brewer 2: Advice for cartography. <http://colorbrewer2.org/> - accessed 15/12/2010
- British Petroleum (BP), (2009). BP Statistical Review of World Energy. <http://www.bp.com/statisticalreview> - accessed on 30/01/2010
- British Petroleum (BP), (2012). BP Statistical Review of World Energy June 2012. <http://www.bp.com/statisticalreview> - accessed on 16/03/2013
- Brouwer, I. D., Hoorweg, J. C. & Van Liere, M. J. (1997). When households run out of fuel: responses of rural households to decreasing fuel wood availability, Ntcheu District, Malawi; *World Development*; 25:255–266.
- Brunsdon, C., Fotheringham, A. S. & Charlton, M.E., (1996). Geographically Weighted Regression: A Method for Exploring Spatial Nonstationarity. *Geographical Analysis*, 28(4): 281-298.
- Brunsdon, C., Fotheringham, S. & Charlton, M., (2007). Geographically Weighted Discriminant Analysis. *Geographical Analysis*, 39(4): 376-396.
- Bugaje, I.M. (2006).Renewable energy for sustainable development in Africa: a review. *Renewable and Sustainable Energy Reviews*, 10 (6): 603–612. <http://dx.doi.org/10.1016/j.rser.2004.11.002>
- Bulte, E.H. & Brunnschweiler, C.N. (2008). The resource curse revisited and revised: A tale of paradoxes and red herrings. *Journal of Environmental Economics and Management*, 55: 248–264.
- Campbell, J.B. (2002). Introduction to remote sensing. Third edition. The Guilford Press, New York.
- Cardoso, M.B., Ladio, A .H. & Lozada, M. (in press). Fuelwood consumption patterns and resilience in two rural communities of the northwest Patagonian steppe, Argentina, *Journal of Arid Environments* (2012), <http://dx.doi.org/10.1016/j.jaridenv.2012.09.013>.
- Casse, T., Milhøj, A., Ranaivoson , S. & Randriamanarivo, J.R. (2004). Causes of deforestation in southwestern Madagascar: what do we know? *Forest Policy and Economics*, 6: 33–48.
- Cazull, S.E.B. & Cialla, A. (2002). Land use/ Land cover Map of the central facility of ARM in the Southern Great Plains site using DOE’s multi-spectral Thermal imager satellite images. 12th ARMS Science Team Meeting Proceedings, St. Petersburg, Florida.
- Charlton, M. & Fotheringham, A. S. (n.d). Geographically Weighted Regression. A Tutorial on using GWR in ArcGIS 9.3. National Centre for Geocomputation (NGC). National University of Ireland Maynooth , Ireland . <http://ncg.nuim.ie/ncg/GWR/>. Accessed 25/10/2011.
- Charlton, M., Brunsdon, C. & Fotheringham, A. S. (n.d). Geographically Weighted Regression. ESRC National Centre for Research Methods NCRM Methods Review Papers NCRM/006.
- Chapter 24 Logistic Regression. (n.d.). <http://www.uk.sagepub.com/burns/website%20material/Chapter%2024%20-%20Logistic%20Regression.pdf>- accessed 19/07/ 2012.

- Cherp, A., Jewell, J. & Goldthau, A. (2011). Governing global energy: systems, transitions, complexity, *Global Policy*, 2(1): 75 – 88.
- Chomitz, K.M. & Griffiths, C. (2001). An economic analysis and simulation of woodfuel management in the Sahel. *Environmental and Resource Economics*, 19: 285–304.
- Chothia, F. (2012). Who are Nigeria's Boko Haram Islamists? BBC African Service, 11 January 2012. <http://www.bbc.co.uk/news/world-africa-13809501>. accessed 10/12/2012.
- Chowdhury, R. R. (2006-B). Driving forces of tropical deforestation: The role of remote sensing and spatial models. *Singapore Journal of Tropical Geography*, 27: 82–101.
- Christensen, M., Rayamajhi, S. & Meilby, H. (2009). Balancing fuelwood and biodiversity concerns in rural Nepal. *Ecological Modelling*, 220 (4): 522-532.
- Cline-Cole , R. (1997) . Promoting (Anti-) Social Forestry in Northern Nigeria? *The Review of African Political Economy*, 24 (74): 515-536.
- Cline-Cole, R. (1998). Knowledge claims and landscape: alternative views of the fuelwood-degradation nexus in northern Nigeria. *Environment and Planning D-Society & Space* 16 (3): 311-346.
- Cline-Cole, R. A., Falola, J. A., Main, H. A. C., Mortimore, M. J., Nichol, J. E. & O'Reilly, F. D. (1987). Wood fuel in Kano, final report of the rural energy research project. Bayero University, Kano, Nigeria. Report submitted to the United Nations university Development studies division. <http://www.odl.org.uk/fpeg/publications/greyliterarture/fuelwood/Clinecole/index.html> - accessed 06/01/2010.
- Cline-Cole, R. A., Falola, J. A., Main, H. A. C., Mortimore, M. J., Nichol, J. E. & O'Reilly, F. D. (1990a). Wood fuel in Kano. Tokyo: United Nations University Press.
- Cline-cole, R. A., Main, H. A. C. & Nichol, J.E. (1990b). On Fuelwood Consumption, Population-Dynamics and Deforestation in Africa. *World Development*, 18(4): 513-527.
- Cline-Cole, R.A., Falola, J.A, Main, H.A.C, Mortimore, M.J. , Nichol, J.E. & O'Reilley, F.D. (1988). Woodfuel in Kano: The Urban –Rural Conflict. Social forestry network: Network paper 7b.
- Clissett, P. (2008). Continuing Professional Education:Evaluating Qualitative Research. *Journal of Orthopaedic Nursing*, 12: 99–105.
- Cohen, W.B., Fiorella, M., Gray, J., Helmer, E. & Anderson, K. (1998). An Efficient and Accurate Method for Mapping Forest Clearcuts in the Pacific Northwest Using Landsat Imagery. *Photogrammetric Engineering & Remote Sensing*, 64 (4): 293-300.
- Cooke, P., Kohlin, G. & Hyde, W.F. (2008). Fuelwood, forests and community management - evidence from household studies. *Environment and Development Economics*, 13: 103-135.
- Coppin, P. R. & Bauer, M. E. (1996). Change Detection In Forest Ecosystems With Remote Sensing Digital Imagery. *Remote Sensing Reviews*, 13:207-234.
- Couture, S., Garcia, S. & Reynaud. A. (2012). Household energy choices and fuelwood consumption: An econometric approach using French data. *Energy Economics*, 34 :1972–1981

- Cromley, E.K. & Cromley, R.G. (1996). An Analysis of Alternative Classification Atlas Mapping Schemes for Medical atlas mapping. *European Journal of cancer*, 32A (9):1551-1559.
- Cromley, R. G. & Mrozinski, R. D. (1997). An Evaluation of Classification Schemes Based on the Statistical Versus the Spatial Structure Properties of Geographic Distributions In Choropleth Mapping. Technical paper. Department of Geography, University of Connecticut, Storrs, USA. <http://mapcontext.com/autocarto/proceedings/auto-carto-13/pdf/an-evaluation-of-classification-schemes-based-on-the-statistical.pdf> - Accessed 25/03/2011.
- Cuthbert, A. L., & Dufoumaud, C. M. (1998). An econometric analysis of fuelwood consumption in Sub-Saharan Africa. *Environment and Planning*, 30 (4): 721-729.
- Dada, P. (2012). Fuel subsidy scam: Trial of Ahmadu Ali's son fixed for Nov 12. *Leadership Newspaper*, 31/10/2012 edition.
- David, W. D. & Tiefelsdorf, E.M. (2005). Multicollinearity and correlation among local regression coefficients in geographically weighted regression. *Journal of Geographical Systems*, 7: 161–187.
- Deichmann, U., Meisner, C., Murray, S. & Wheeler, D.(2011). The economics of renewable energy expansion in rural Sub-Saharan Africa. *Energy Policy* 39 : 215–227.
- Dent, B. R. (1985). *The Principles of Thematic Map Design*. MA: Addison-Wesley, Reading.
- Diagnostic Mission, (2007). Achieving the International Tropical Timber Council (ITTO) Objective 2000 and sustainable forest management in Nigeria. Report submitted to the ITTO, 2(Xxix) 2006 (ITTC(XLIII)/6). Forty-third session 5-10, Yokohama, Japan.
- Di Gregorio, A. & Jansen, L.J.M (2000). Land Cover Classification System (LCCS): Classification concepts and user manual. FAO, Rome.
- Dorling, D. (1993). Map design for census mapping. *The Cartographic Journal*, 30:167-183.
- Dolisca, F., McDaniel, J.M., Teeter, L. D. & Jolly, C.M. (2007). Land tenure, population pressure, and deforestation in Haiti: The case of Fore[^] t des Pins Reserve. *Journal of Forest Economics*, 13: 277–289. doi:10.1016/j.jfe.2007.02.006
- Drigo, R. & Nzabanita, V. (2011). WISDOM Rwanda:Spatial analysis of woodfuel production and consumption in Rwanda applying the WISDOM methodology. FAO Forestry Department – Wood Energy. Rome. <http://www.fao.org/docrep/013/ma223e/ma223e00.pdf> - accessed 27/03/2013.
- Drigo,R. & Salbitano, F., (2008). Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) for Cities: Analysis of wood energy and urbanization using WISDOM methodology. FAO Forestry Department. Rome. <ftp://ftp.fao.org/docrep/fao/010/i0152e/i0152e00.pdf>- accessed 10/12/2011.
- Dunn, R. (1987).Variable-Width Framed Rectangle Charts for Statistical Mapping. *The American Statistician*, 41(2): 153-156.
- Dykes, J. & Unwin, D. (n.d). Maps of the Census: a rough guide. <http://www.agocg.ac.uk/reports/visual/casestud/dykes/dykes.pdf>. - accessed 01/08/2011.
- Echenim, S. (2013). Passengers Overwhelm NRC On Lagos-Kano Route. *Leadership Newspaper*, 20/01/2013 edition.

- Eckholm, E. (1975). The other energy crisis: Firewood. Worldwatch Paper 1. Worldwatch Institute, Washington, DC.
- Eckholm, E., Foley, G., Bernard G. & Timberlake, L. (1984). Fuelwood: The energy crisis that won't go away. Earthscan and International Institute for Environment and Development (IIED), London.
- Ebdon, D. (1985). Statistics in Geography. 2nd Edition, Blackwell Publishers Ltd, Oxford, UK.
- Ehinomen, C. & Adeleke, A. (2012). An assessment of the distribution of Petroleum products in Nigeria. *E3 Journal of Business Management and Economics*, 3(6): 232-241.
- Enogholase, G. (2011). Kerosene Explosion Kills father, daughter. *Vanguard Newspaper*. 12/06/2011 edition.
- Eroke, L. (2012). 20.3 Million Nigerians currently Unemployed, Statistics reveal. *Thisday Newspaper*, 8/10/2012 edition.
- ESRI, (2010). Spatial Statistics toolbox sample applications. (http://help.arcgis.com/en/arcgisdesktop/10.0/help/#/Spatial_Statistics_toolbox_sample_applications/005p00000004000000/) - accessed 09/10/2011
- Festus, I. A. (2012). Appraisal of the causes and consequences of human induced deforestation in Ekiti state, Nigeria. *Journal of Sustainable Development in Africa*, 14(3): 37-52.
- Federal Ministry of Environment of Nigeria (FMEN), (2007). National Action Programme to Combat Desertification. <http://www.unccd.int/actionprogrammes/africa/national/2001/nigeria-eng.pdf> - Accessed 17/06/2010.
- Field, A. (2009). Discovering Statistics Using SPSS. Third Edition, SAGE Publications Ltd, London.
- Fleuret, A. (1983). Factors affecting fuelwood use in Taita, Kenya. A paper presented at the African Association meeting, Boston, December 1983. <http://www.odi.org.uk/resources/libraries/forestry-grey-literature/fleuret.pdf>- accessed 21/11/2009.
- Florini, A. & Sovacool, B.K. (2009). Who governs energy? The challenges facing global energy governance. *Energy Policy*, 37(12): 5239 – 5248.
- Food & Agriculture Organization of the United Nations (FAO), (2000). Forest Resource Assessment 2000. On definitions of forest and forest change. Rome, FAO.
- Food & Agriculture Organization of the United Nations (FAO), (2003). Experience of implementing national forestry programmes in Nigeria. Sustainable forest management programmes in African ACP countries. <http://www.fao.org/DOCREP/005/AC918E/AC918E04.htm> - accessed on 10/01/2010.
- Food & Agriculture Organization of the United Nations (FAO), (2007). Forests and Energy: New Challenges in Sustainable Forest Management. Committee on Forestry, Eighteenth Session. Rome, FAO. <ftp://ftp.fao.org/docrep/fao/meeting/013/j8902e.pdf>. accessed 20/1/2010.
- Food & Agriculture Organization of the United Nations (FAO), (2010a). Global Forest Resource Assessment Main Report 2010. FAO Forestry paper, 163.

- http://foris.fao.org/static/data/fra2010/FRA2010_Report_en_WEB.pdf - accessed 25/07/2011.
- Food & Agriculture Organization of the United Nations (FAO), (2010b). Global Forest Resources Assessment 2010 Country Report Nigeria. FRA2010/151. Rome, FAO.
- Food & Agriculture Organization of the United Nations (FAO), (2009a). Wood Energy. <http://www.fao.org/forestry/energy/en/> - accessed 28/09/2011.
- Food & Agriculture Organization of the United Nations (FAO), (2009b). Land Cover of Nigeria- Globcover Regional 46 Classes. <http://www.africover.org>. Accessed 29th-9-11.
- Food & Agriculture Organization of the United Nations (FAO), (2011a). Wood energy. <http://www.fao.org/forestry/energy/en/> Accessed on 28/09/2011.
- Food & Agriculture Organization of the United Nations (FAO), (2011b). State of the World's Forests. Rome, FAO.
- Forestry Management Evaluation and Coordinating Unit (FORMECU), (1996). Nigerian Forestry Action Program., Federal Ministry of Agriculture and Natural Resources. Abuja.
- Forestry Management Evaluation and Coordinating Unit (FORMECU), (n.d). Nigerian Ecological Zones. Federal Department of Forestry, Federal Ministry of Agriculture and Rural Development, Abuja.
- Forsyth, T. (2003). Critical political ecology : the politics of environmental science- Routledge, London.
- Fotheringham, A.S., Brunsdon, C. & Charlton, M. (2002). Geographically weighted regression: The Analysis of Spatially Varying Relationships Wiley: Chichester.
- Garuba, D. S. (2010). Trans-Border Economic Crimes, Illegal Oil Bunkering and Economic Reforms in Nigeria, Policy Brief Series, no. 15, October, Global Consortium on Security Transformation. http://www.securitytransformation.org/gc_publications.php - accessed on 17/5/2011.
- Ghilardi, A., Guerrero, G., & Masera, O. (2007). Spatial analysis of residential fuelwood supply and demand patterns in Mexico using the WISDOM approach. *Biomass & Bioenergy*, 31(7), 475-491.
- Ghilardi, A., Guerrero, G. & Masera, O. (2009). A GIS-based methodology for highlighting fuelwood supply/demand imbalances at the local level: a case study for Central Mexico. *Biomass Bioenergy*, 33(6-7): 957-972.
- Gill, J. (1985). Stoves and deforestation in developing countries. Paper presented at the UK-ISES conference, *Energy for development – what are the solutions*, Reading University, 13 December 1985. <http://www.odi.org.uk/resources/libraries/forestry-grey-literature/gill.pdf> - accessed on 15/11/2009.
- Hardin, G. (1968). The tragedy of the commons. *Science* 162:1243- 1248.
- Hardin, C.L & Maffi, L. (1997). Color categories in thought and language. Cambridge University Press , Cambridge.
- Hassan, R., Hertzler, G. & Benhin, J.K.A. (2009). Depletion of forest resources in Sudan: Intervention options for optimal control. *Energy Policy* 37: 1195–1203.

doi:10.1016/j.enpol.2008.10.049

- Hegan, R. L., Hauer, G. & Luckert, M. K. (2003). Is the tragedy of the commons likely? Factors preventing the dissipation of fuelwood rents in Zimbabwe. *Land Economics*, 79(2): 181-197.
- Helldén, U. & Tottrup, C. (2008). Regional desertification: A global synthesis. *Global and Planetary Change*, 64: 169–176.
- Heltberg, R., Arndt, T. C., & Sekhar, N. U. (2000). Fuelwood consumption and forest degradation: a household model for domestic energy substitution in rural India. *Land Economics*, 76(2): 213-232.
- Hess, T.M., Stephens, W. & Maryah, U.M. (1995). Rainfall trends in the North East Arid Zone of Nigeria 1961-1990. *Agricultural and Forest Meteorology*, 74: 87-97.
- Hess, T. M., Stephens, W. & Thomas, G. (1996). Modelling NDVI from decadal rainfall data in the North East Arid Zone of Nigeria. *Journal of Environmental Management* 48: 249–261.
- Hiemstra-van der Horst, G. & Hovorka, A. J. (2009). Fuelwood: The "other" renewable energy source for Africa?. *Biomass & Bioenergy*, 33(11): 1605-1616.
- Hyman, E. L. (1993). Forestry policies and programs for fuelwood supply in Northern Nigeria. *Land Use Policy* 10(1): 26-43.
- Hyman, E. L. (1994). Fuel substitution and efficient woodstoves - are they the answers to the fuelwood supply problem in Northern Nigeria. *Environmental Management*, 18(1): 23-32.
- Hyman, E. L. (1983). Analysis of the Woodfuels Market - a Survey of Fuelwood Sellers and Charcoal Makers in the Province of Ilocos-Norte, Philippines. *Biomass* 3(3): 167-197.
- Hutcheson, G. & Sofroniou, N. (1999). The multivariate social scientist. SAGE Publications Ltd., London.
- Idemudia, U. (2012). The resource curse and the decentralization of oil revenue: the case of Nigeria. *Journal of Cleaner Production*, 35: 183-193.
- Idris, N.A., Lamin, H.S., Ladan, M.J. & Yusuf, B.H. (2012). Nigeria's Wind Energy Potentials: the Path to a Diversified Electricity Generation-Mix. *International Journal of Modern Engineering Research (IJMER)*, 2 (4):2434-2437.
- Imam, N. (2013). "Oil exploration: Northern governors must ensure paradigm shift". *Daily Trust Newspaper*, 17/04/ 2013 edition.
- Independent National Electoral Commission (INEC), (2011).provisional Voter's Registration Figures: 21:02:2011 (5254). <http://www.inecnigeria.org/Provisional-Voter%E2%80%99s-Registration-Figures-21022011/> - accessed 20/10/2012.
- Innes, J. L. & Koch, B. (1998). Forest biodiversity and its assessment by remote sensing. *Global Ecology and Biogeography*, 7 (6): 397–419.
- InSites, (2007). Module 5: Tips for Analyzing Qualitative Data. http://www.insites.org/CLIP_v1_site/downloads/PDFs/TipsAnalzQualData.5D.8-07.pdf - accessed 28/105/12.
- International Energy Agency (IEA), (2011). Energy for all: financing access for the poor – special early excerpt of the World Energy Outlook 2011. OECD/IEA, Paris.

- IRIN news service, (2013). NIGERIA: Farmer-pastoralists' dash leaves 32 dead. The Humanitarian News and Analysis, IRIN. <http://www.irinnews.org/Report/87525/NIGERIA-Farmer-pastoralists-dash-leaves-32-dead> - accessed 17/01/2013.
- Isah, A. (2013). \$620,000 Bribery Scam: AGF Bows to Keyamo, Begins Trial of Farouk Lawan. *Leadership Newspaper*, 28/01/2013 edition.
- Jaimes, N. B. P., Sendra, J.B., Montserrat Gómez Delgado, M.G. & Plata, R. F. (2010). Exploring the driving forces behind deforestation in the state of Mexico (Mexico) using geographically weighted regression. *Applied Geography*, 30 :576–591.
- James, A. & Aadland, D. (2011). The curse of natural resources: An empirical investigation of U.S. counties. *Resource and Energy Economics* 33: 440–453.
- Jan, I. (2012). What makes people adopt improved cookstoves? Empirical evidence from rural northwest Pakistan. *Renewable and Sustainable Energy Reviews*, 16: 3200– 3205.
- Jelwic N.E. & Van Vegt, J.A. (1981). A pain in the neck: The firewood situation in South-Western Kgatleng, Botswana. National Institute of Development and Cultural Research (NIR) - Research Notes No. 5. University College of Botswana, Gaborone.
- Jiang, L. & O'Neill, B.C. (2004). The energy transition in rural China. *International Journal of Global Energy Issues*, 21(1/2): 2-26.
- Jha, C.S. & Unni, N.V.M. (1994). Digital change detection of forest conversion of a dry tropical Indian forest region. *International Journal of Remote Sensing*, 15,(13): 2543-2552.
- John, M. (2012). NUPENG Calls Off Strike. *Leadership Newspaper*, 24/08/2012 edition.
- Johnston, R.J., Gregory, D., Pratt, G. & Watts, M. (Eds). (2000). The Dictionary of Human Geography (4th ed). Oxford: Blackwell Publishing.
- Jones, C. (2008). Modelling health related behaviours using geodemographics: applications in social marketing and preventive health. Unpublished Doctoral Thesis, University College London, London.
- Júnior, W.S.F., Ladio, A.H. & Albuquerque, U.P. (2011). Resilience and adaptation in the use of medicinal plants with suspected anti-inflammatory activity in the Brazilian northeast. *Journal of Ethnopharmacology*, 138: 238-252.
- Kano, M.S. (2012). Kano to import petroleum products from Niger Republic. *PUNCH Newspaper*, 13/09/2012 Edition.
- Kaschula, S. A., Twine, W. C. & Scholes, M.C. (2005). The effect of catena position and stump characteristics on the coppice response of three savannah fuelwood species. *Environmental Conservation*, 32(1): 76-84.
- Kar, D. & Freitas, S. (2012). Illicit financial flows from Developing Countries: 2001-2010. Global Financial Integrity Report, Washington.
- Kazaure, M. U. (2003). Nigeria: Marketers allege NNPC under supply North with petroleum products. *Daily Trust Newspaper*, 01/09/ 2003 Edition.
- Kebede E., Kagochi, J. & Jolly, C.M. (2010). Energy consumption and economic development in Sub-Sahara Africa. *Energy Economics*, 32 : 532–537

- Kersten, I., Baumbach, G., Oluwole, A.F., Obioh, I.B. & Ogunsola, O.J. (1998). Urban and rural fuelwood situation in the tropical rain-forest area of South-West Nigeria. *Energy*, 23(10): 887-898.
- Kituyi, E. & Kirubi, C. (2003). Influence of diet patterns on fuelwood consumption in Kenyan Boarding schools and implications for data and energy policies. *Energy Conversion and Management*, 44: 1099-1109.
- Knafl, K. A. & Howard, M. J. (1984). Interpreting and Reporting Qualitative Research. *Research in Nursing and Health*, 7: 17-24.
- Kowsari, R. & Zeriffi, H. (2011). Three dimensional energy profile: A conceptual framework for assessing household energy use. *Energy Policy*, 39: 7505–7517.
- Kumar, M. & Sharma, C. M. (2009). Fuelwood consumption pattern at different altitudes in rural areas of Garhwal Himalaya. *Biomass & Bioenergy*, 33(10): 1413-1418.
- Kummer, D. (1991). *Deforestation in the Postwar Philippines*. University of Chicago Press, Chicago, IL.
- Landau, S. & Everitt, B.S. (2004). A handbook of statistical analyses using SPSS. Chapman & Hall/CRC, Florida, USA.
- Leach, G. (1987). Energy and the urban poor. *The IDS bulletin*, 18,1.
- Leadership Editorial, (2012). Corruption: The Writing on Nigeria's Wall. *Leadership Newspaper*, 13/11/2012 edition.
- Leimgruber, P., Christen, C.A. & Laborderie, A. (2005). The impact of Landsat satellite monitoring on conservation biology. *Environmental Monitoring and Assessment*, 106: 81-101.
- Legros, G., Havet, I., Bruce, N. & Bonjour, S. (2009). The energy access situation in Developing Countries. A review focusing on the least Developed Countries and Sub-Saharan Africa. UNDP Environment and Energy Group, Bureau for Development Policy. New York. www.undp.org/energyandenvironment- accessed on 01/12/11.
- Lenzen, M., Dey, C. & Foran, B. (2004). Analysis of energy requirements of Sydney Households. *Ecological Economics*, 49: 375–399.
- Lillesand, T.M. & Kiefer, R.W. (2000). *Remote sensing and image interpretation*. John Wiley and Sons, New York.
- Lillesand, T. M., Kiefer, R. W. & Chipman, J. W. (2004). *Remote sensing and image interpretation*. John Wiley and Sons, New York.
- Linde-Rahr, M. (2003). Property rights and deforestation: The choice of fuelwood source in rural Viet Nam. *Land Economics* 79(2): 217-234.
- Lyon, F. & Porter, G. (2009). Market institutions, trust and norms: exploring moral economies in Nigerian food systems. *Cambridge Journal of Economics*, 33(5): 903-920.
- Maconachie, R. (2007). Urban growth and land degradation in developing cities: change and challenges in Kano, Nigeria. Aldershot, UK: Ashgate.

- Maconachie, R., Tanko, A. & Zakariya, M. (2009). Descending the energy ladder? Oil price shocks and domestic fuel choices in Kano, Nigeria. *Land Use Policy*, 26 (4): 1090-1099.
- Madubansi, M. & Shackleton, C. M. (2007). Changes in fuelwood use and selection following electrification in the Bushbuckridge lowveld, South Africa. *Journal of Environmental Management*, 83, (4): 416–426. <http://dx.doi.org/10.1016/j.jenvman.2006.03.014>
- Mahiri, I. & Howorth, C. (2001). Twenty years of resolving the irresolvable: Approaches to the fuelwood problem in Kenya. *Land Degradation & Development*, 12(3), 205-215.
- Mahiri, I. O. (2003). Rural household responses to fuelwood scarcity in Nyando District, Kenya. *Land Degradation & Development*, 14(1): 163-171.
- Marklund, M. (N.D). Black liquor recovery: how does it work? (ETC). http://www.etcpitea.se/blg/document/PBLG_or_RB.pdf - accessed 21/02/13.
- Marshall, C. & Rossman, G.B. (1999). Designing Qualitative Research. 3rd Edition, Sage Publications, Inc., London.
- Masera, O.R., Drigo R. & Trossero, M.A. (2003). Woodfuels Integrated Supply/Demand Overview Mapping – WISDOM. FAO Forestry Department. Rome. <http://www.fao.org/DOCREP/005/Y4719E/Y4719E00.HTM> - accessed 10/09/11.
- Mauz, K. (2002). Accuracy assessment, background and rationale for the procedure. Adapted from the original "More on generating Random Points in Imagine": Observations and cautionary Tales. Arizona Remote Sensing Center, Office of Arid Lands Studies, University of Arizona, Tucson. http://arisc.arid.arizona.edu/resources/image_processing/accuracy/background.html - accessed 13/01/12.
- Mather, A. (2003). Book reviews: Global forest resources assessment 2000 main report FAO forestry paper 140, FAO, Rome, 2001. *Land Use Policy*, 20 : 195–200.
- Matsika, R., Erasmus, B.F.N. & Twine, W.C. (in press). Double jeopardy: The dichotomy of fuelwood use in rural South Africa. *Energy Policy* (2012). <http://dx.doi.org/10.1016/j.enpol.2012.10.030>
- Max Lock Group Nigeria (MLGN), (1976). *Potiskum: Surveys and planning reports for Bomo, Bauchi, and Gongola state Governments between 1973-1976*. Warminster Press Ltd., UK.
- Mennis, J. (2006) .Mapping the results of geographically weighted regression. *The Cartographic Journal*, 43(2):171-179.
- Metz , H.C. (ed) (1991). *Nigeria: A Country Study*. Washington: GPO for the Library of Congress, 1991. <http://countrystudies.us/nigeria/> - accessed 28/09/11.
- McClintock, J. (1987). Fuelwood scarcity in rural Africa: Possible remedies. Vol. 1-Main text. Centre for Agricultural Strategy, University of Reading.
- McCrary, J. K., Walsh, B. & Hammett, A. L. (2005). Species, sources, seasonality, and sustainability of fuelwood commercialization in Masaya, Nicaragua. *Forest Ecology and Management*, 205(1-3): 299-309.
- Middleton, N. (2008). The Global Casino: An introduction to Environmental Issues. London, Hodder Education.

- Mlambo, D., Huizing, H. , Mapaure , I. & Savanhu, G.M. (2003). Fuelwood availability and consumption in a semi-arid savanna, Zimbabwe. *Energy and the Environment*, 7: 123-130.
- Morgan,W.B. (1978). Development and the fuelwood situation in Nigeria. *Geojournal*, 2(5): 437-442.
- Muhammad, H. (2011). Kerosene price hits N200 per litre. *Daily Trust Newspaper*, 26th /01/2011 Edition.
- Mortimore, M. J. (1990). Policy issues. In R. A. Cline-Cole et al. (Eds.), *Wood fuel in Kano*. Tokyo: United Nations University Press.
- Mortimore, M. J. & Adams, W.M. (2001). Farmer adaptation, change and crisis in the Sahel. *Global Environmental Change*, 11 : 49-57.
- Motel, P. C., Pirard, R. & Combes, J.L. (2009). A methodology to estimate impacts of domestic policies on deforestation: Compensated Successful Efforts for “avoided deforestation” (REDD). *Ecological Economics*, 68: 680 – 691.
- Nash, R. & Luttrell, C. (2006). Crisis to context: The fuelwood debate. Forest Policy and Environment Programme. www.odifpeg.org.uk/publications/greyliterature - accessed 10/12/2009.
- National Aeronautics & Space Administration (NASA), (2011). The Numbers behind Landsat. <http://landsat.gsfc.nasa.gov/data/> - accessed 30/07/2011.
- National Bureau of Statistics (NBS), (2008a). Poverty profile for Nigeria. Abuja: NBS Headquarters.
- National Bureau of Statistics (NBS), (2009). Social Statistics in Nigeria. <http://www.nigerianstat.gov.ng>. - accessed 25/03/2012.
- National Bureau of Statistics (NBS), (2010). Electricity Supply and Demand Statistics. <http://www.nigerianstat.gov.ng/index.php/pages/sectorStatistics>- accessed 25/6/11.
- National Bureau of Statistics (NBS), (2012). Population and Vital Statistics. <http://www.nigerianstat.gov.ng> - accessed 25/03/2012.
- National Population Commission (NPC), (2009a). 2006 Population and Housing Census of the Federal Republic of Nigeria Priority Tables (Volume I): National and State Population and Housing Tables. Abuja, Nigeria.
- National Population Commission of Nigeria (NPC), (2009b). 2006 facts and figures. www.Population.gov.ng - accessed 19/01/2010.
- National Population Commission (NPC), (2010). 2006 Population and housing census of the Federal Republic of Nigeria priority tables (LGA) (Volume II): Housing Characteristics and Amenities Table. Abuja, Nigeria.
- National Population Commission (NPC) and ICF Macro, (2009). Nigeria Demographic and Health Survey 2008. Abuja, Nigeria: National Population Commission and ICF Macro.
- Nda-Isaiah, S. (2012). This stealing is too much! *Leadership Newspaper*, 12/11/2012 edition.

- Nelson, G. C. & Geoghegan, J. (2002). Deforestation and land use change: Sparse data environments. *Agricultural Economics*, 27(3): 201-216.
- News Agency of Nigeria (NAN), (2012a). Tribunal upholds 2006 Census figures for 3 LGs In Kano state. *Leadership Newspaper*, 08/11/2012 edition
- News Agency of Nigeria (NAN), (2012b). Agric transformation Agenda boosts food supply by 8.1m tonnes- Minister. *Leadership Newspaper*, edition, 16/10/2012.
- News Agency of Nigeria (NAN), (2012c). U.S Narcotics officer seeks speedy prosecution of corrupt Nigerians. *Leadership Newspaper*, 18/12/2012 edition.
- News Agency of Nigeria (NAN), (2012d). Labour minister allays fear about fuel scarcity. *Leadership Newspaper*, 11/10/2012 edition.
- News Agency of Nigeria (NAN), (2012e). Oil marketers resume importation – PPMC. *Leadership Newspaper*, 4/02/2012 edition.
- News Agency of Nigeria (NAN), (2013a). BPE to handover PHCN to successor companies In 2nd quarter of 2013 – Official. *Leadership Newspaper*, 26/01/2013 edition.
- News Agency of Nigeria (NAN), (2013b). Techno oil introduces gas stoves to discourage firewood usage. *Leadership Newspaper*, 09/02/2013 edition.
- Nichol, J. E. (1989). Ecology of Fuelwood Production in Kano Region, Northern Nigeria. *Journal of Arid Environments*, 16(3): 347-360.
- Nichol, J. E. (1990). Dynamics of Indigenous Fuelwood Production Systems - an Analysis of Kano, Nigeria. *Singapore Journal of Tropical Geography*, 11(1): 43-55.
- Nigerian Constitution, (1990). Land use act: laws of the Federation of Nigeria. <http://www.nigeria-law.org/Land%20Use%20Act.htm> - accessed 02/02/2011.
- Nigerian Gas Company (NGC), (2009). About us. <http://www.ngc-nnpcgroup.com/index.php?page=about-us> - accessed 26/07/2011.
- Nigerian Gas Company Limited (NGC), (2011a). Commissioning of 128km South-South Gas Pipeline System in Calabar..... Powered By NGC. [Http://www.Ngc-nnpcgroup.Com/Category/News/](http://www.Ngc-nnpcgroup.Com/Category/News/) - accessed on 27/11/2012.
- Nigerian Gas Company Limited (NGC), (2011b). About NGC. <Http://www.Ngc-Nnpcgroup.Com/Category/News/> - accessed 27/11/2012.
- Nigeria Good News , (2013) . Oil in Northern Nigeria – FG Provides U.S.\$100 Million for Exploration. *Nigeria Good News Newspaper*, 27/03/2013 edition. <http://www.nigeriagoodnews.com/oil-in-the-northern-nigeria-fg-provides-u-s-100-million-for-exploration/> - accessed 12/05/2013.
- Nigerian National Petroleum Corporation (NNPC), (2010). Annual statistical bulletin. Corporate Planning & Strategy Division (CP&S). NNPC ASB 2010 – 1st Edition. www.nnpcgroup.com - accessed 25/10/2010.
- Nigerian National Petroleum Corporation (NNPC), (2013). NNPC alerts on adulterated kerosene in Delta, Edo. Public Relations, NNPC in the news. [States.http://www.nnpcgroup.com/PublicRelations/NNPCinthenews/tabid/92/articleType/](http://www.nnpcgroup.com/PublicRelations/NNPCinthenews/tabid/92/articleType/)

- ArticleView/articleId/275/NNPC-Alerts-on-Adulterated-Kerosene-in-Delta-Edo-States.aspx-
accessed on 15/03/2013.
- Nigerian Railway Corporation (NRC), (NRC, 2010). About Nigerian railway corporation.
<http://www.nrc-ng.org/aboutnrc.php> - accessed 10/05/2013.
- Nmodu, A. (2013). NRC begins cargo services after 10 years. *Leadership Newspaper*, 18/01/2013
edition.
- Nnabugwu, F. (2012). Nigeria was last mapped 39 years ago-Surveyor-General. *Vanguard
Newspaper*, 07/02/ 2012 edition.
- Nuhu-Koko, A. A. (2007). Nigeria's Unending Fuels Price Crises – Issues and Matters Arising (Parts
1-4 of 5). The Shehu Shagari World Institute for Leadership and Good Governance (SSWI),
Sokoto, Nigeria. Unpublished document.
[http://www.nigeriavillagesquare.com/artides/abubakar-a-nuhu-koko/nigerias-unending-
fuels-price-crises-issues-and-matters-arising-parts-1-4-of-5.html](http://www.nigeriavillagesquare.com/artides/abubakar-a-nuhu-koko/nigerias-unending-fuels-price-crises-issues-and-matters-arising-parts-1-4-of-5.html) - accessed 12/6/2011.
- Nwafor , M., Ogujiuba , K. & Asogwa, R. (2006). Does subsidy removal hurt the poor. Working
Paper Series, Secretariat for Institutional Support for Economic Research in Africa (SISERA).
African Institute for Applied Economics (AIAE). Senegal. <http://www.crdi.ca/sisera->
accessed 02/07/2011.
- Obioha, E. E. (2008). Change in tenure pattern and customary land practices among Igbo
community in Southeastern Nigeria. *Anthropologist*, 10(1): 45-53.
- Odeleye, J. A. (2000). Public- Private Participation to Rescue Railway Development in Nigeria.
Japan Railway & Transport Review, 23: 42-49.
- Odihi, J. (2003). Deforestation in afforestation priority zone in sudano-sahelian Nigeria. *Applied
Geography*, 23: 227-259.
- Odiogor, H. (2010). Special report on desertification in Nigeria: The sun eats our land.
<http://odili.net/news/source/2010/may/4/300.html> - *Vanguard news paper*, accessed
04/05/ 2010.
- Odoh, S. I. & Chigozie, C. F. (2012). Climate change and conflict in Nigeria: a theoretical and
empirical examination of the worsening incidence of conflict between Fulani herdsmen and
farmers in northern Nigeria. *Arabian Journal of Business and Management Review (Oman
chapter)*, 2 (1): 110-124.
- Odularu, G.O. & Okonkwo, C. (2009). Does energy consumption contribute to economic
performance? Empirical evidence from Nigeria. *Journal of Economics and International
Finance*, 1 (2): 44-58.
- Ogunmola, T. (2012). Subsidy payment controversy: NUPENG threatens nationwide strike.
Leadership Newspaper , 21/08/2012 edition.
- Ogunkunle, A. T. J., & Oladele, F. A. (2004). Ethnobotanical study of fuelwood and timberwood
consumption and replenishment in Ogbomoso, Oyo State, Nigeria. *Environmental
Monitoring and Assessment*, 91 (1-3): 223-236.
- Ogbonnikan, F. (2012). 6 more marketers arrested over N23.6bn fuel subsidy scam. *Leadership
newspaper*, 17/11/2012 edition.

- Ojo, A., Vickers, D. & Ballas, D. (2010). The segmentation of Local Government Areas: Creating a new Geography of Nigeria. *Applied Spatial Analysis and Policy*: 1-25.
- Okpi, A. & Leke, (2012). "The main intrigues of fuel price protests". *PUNCH Newspaper*, 8/1/2012 edition.
- Okonjo-Iwela, N. (2012). Subsidy scam: FG recovers N29bn from suspects. *Business edition of Leadership Newspaper*, 03/12/2012 edition.
- Olayiwola, L.M. & Adeleye, O.A. (2005). Rural Infrastructural Development in Nigeria: Between 1960 and 1990 – Problems and Challenges. *Journal of Social Science*, 11 (2): 91-96.
- Olanrewaju, S. (, 2011). Oil subsidy removal, what an insult!
<http://www.tribune.com.ng/sun/borderless/4399-oil-subsidy-removal-what-an-insult?tmpl=component&print=1&layout=default&page> - *Sunday Tribune News paper*, 10/07/2011 edition.
- Olise M. & Nria-Dappa, T. (2009). Overcoming Nigeria's energy crisis: towards effective utilisation of associated gas and renewable energy resources in the Niger Delta. Social Development Integrated Centre Social Action Briefing No. 2. Port Harcourt, Nigeria. www.saction.org - accessed 10/07/ 2011.
- Olsson, K. (1985). Fuelwood demand and supply in the Umm Ruwaba/Er Rahad region in N. Kordofan, the Sudan: A study based on field data and Landsat MSS information.
<http://www.odi.org.uk/resources/libraries/forestry-grey-literature/Olsson.pdf> - accessed 2/03/2010.
- Olsson, L., Eklundh, L. & Ardo, J. (2005). A recent greening of the Sahel — trends, patterns and potential causes. *Journal of Arid Environments*, 63 : 556–566.
- Omotoso, F. (2010). Nigerian Fiscal federalism and revenue allocation formula for sustainable development in Niger Delta. *The Social Sciences*, 5(3): 246-253.
- Onimisi, S.A. (2012). Grazing land for transnational citizens? *Leadership Newspaper*, 23/09/2012 edition.
- Onlinenigeria, (2003). People, Population and Settlement.
<http://www.onlinenigeria.com/links/yobesteadv.asp?blurb=383> - accessed 30/09/2013
- Opara, S. (2013). 24 power system failures recorded in 2012 – PHCN. *PUNCH Newspaper*, 31/1/2013 Edition.
- Otubu, A.K. (2008). Deemed grantee and the future of land use act in Nigeria.
<http://ssrn.com/abstract=1123948> accessed 2/2/2011.
- Otuchikere, C. (2013). How communities, vandals frustrate uninterrupted power supply. *Leadership Newspaper*, 24/01/2013 edition.
- Palmer, C. & Macgregor, J. (2009). Fuelwood scarcity, energy substitution, and rural livelihoods in Namibia. *Environment and Development Economics*, 14: 693-715.
- Papka, P.M. & Harris, S.B. (n.d). Wind erosion and land degradation: development initiatives in Nigeria. NEAZDP, Nigeria.

- Parker, R.N. & Asencio, E.K. (2008). GIS and spatial analysis for social sciences: coding, mapping and modeling. Routledge, New York.
- Parry, D. E. & Trevett, J. W. (1979). Mapping Nigeria's vegetation from radar. *The Geographical Journal*, 145 (2): 265-274.
- Paulant, J. (2010). SPSS survival manual: A step by step guide to data analysis using SPSS programme. Univerisity Press /McGraw-Hill, Berkshire.
- Perez-Verdin, G., Kim, Y., Hospodarsky, D. & Tecle, A. (2009). Factors driving deforestation in common-pool resources in northern Mexico. *Journal of Environmental Management*, 90 : 331:340.
- Petroleum Products Pricing Regulatory Authority (PPPRA), (2004). Downstream facilities and retail outlets in Nigeria: Nationwide retail outlets 2006 census – summary distribution by zone <http://www.pppra-nigeria.org/distributionsummary.pdf> - Accessed 12/06/2013.
- Pipelines & Products Marketing Company (PPMC), (2010). PPMC: A subsidiary of NNPC. <http://ppmc.nnpcgroup.com/Home.aspx>- accessed 12/06/2010.
- Population Reference Bureau (PRB), (2009). Human population: Fundamentals of growth and change. Washington DC.
- Porter, G., Harris, F., Lyon, F., Dungs, J. & Adepetus, A. A. (2003). Markets, ethnicity and environment in a vulnerable landscape: The case of small-scale vegetable production on the Jos Plateau, Nigeria, 1991–2001. *The Geographical Journal*, 169(4): 370–381.
- Porter, G., Lyon, F. & Potts, D. (2007). Market institutions and urban food supply in West and Southern Africa: a review. *Progress in Development Studies*, 7(2):115–34
- Potts, J. S. (1999). The information needs and resource requirements of coastal defence groups in England and Wales. Unpublished Doctoral Thesis, University of Wales, Cardiff.
- Powell, R.L., Matzke, N., de Souza Jr., C., Clark, M., Numata, I., Hess, L.L. & Roberts D.A. (2004). Sources of error in accuracy assessment of thematic land-cover maps in the Brazilian Amazon. *Remote Sensing of Environment*, 90 : 221 – 234.
- Prenzel , B. (2004). Remote sensing-based quantification of land-cover and land use change for planning. *Progress in Planning*, 61: 281–299.
- Purefoy,C. (2010). Nigeria's Almajiri children learning a life of poverty and violence. *Connect the World- CNN*, 08/01/ 2010. <http://edition.cnn.com/2010/WORLD/africa/01/07/nigeria.children.radicalization/index.html> - accessed 22/04/2013.
- Radeloff, V. C., Mladenoff, D. J. & Boyce, M. S. (2000). Effects of interacting disturbances on landscape patterns: Budworm defoliation and salvage logging. *Ecological Applications*, 10,(1): 233-247.
- Radwanski, S. A. (1969). Improvement of red acid sands by the neem tree (*azadirachta indica*) in Sokoto, North- Western state of Nigeria. *Journal of Applied Ecology*, 6(3): 507-511.
- Research & Markets, (2011). Electric power sector in Nigeria 2010. <http://bit.ly/hTkUkt> -accessed 28/12/2012.

- REVE, (2010). First wind power project in Nigeria. <http://www.evwind.es/2010/10/12/first-wind-power-project-in-nigeria/7778> - accessed 15/03/2013.
- Revenue Mobilization Allocation & Fiscal Commission (RMAFC), (2012). <http://www.rmafc.gov.ng/#> - accessed 15/11/2012.
- Robbins, P. (2004). Political ecology: Critical introductions to Geography. Oxford, Blackwell publishing Ltd.
- Robson, C. (2011). Real world research: A resource for users of social research method in applied settings. 3rd edition, Chichester, UK, John Wiley & Sons Ltd.
- Roy, P.S., Ranganath, B.K., Diwakar, P.G., Vohra, T.P.S., Bhan, S.K., Singh, I.J. & Pandian, V.C. (1991). Tropical forest type mapping and monitoring using Remote Sensing. *International Journal of Remote Sensing*, 12 (11): 2205-2225.
- Sader, S.A., Bertr, M. & Wilson, E.H. (2003). Satellite change detection of forest harvest patterns on an industrial forest landscape. *Forest Science*, 49(3): 341-353.
- Sader, S.A. & Legaard, K. R. (2008). Inclusion of forest harvest legacies, forest type, and regeneration spatial patterns in updated forest maps: A comparison of mapping results. *Forest Ecology and Management*, 255: 3846–3856.
- Sader, S.A. & Winne, J.C. (1992). RGB-NDVI colour composites for visualizing forest change dynamics. *International Journal of Remote Sensing*, 13: 3055-3067.
- Salako, E.A., Anjorin, S.T., Garba, C.D. & Omolohunnu, E.Z. (2008). A review of neem biopesticide utilization and challenges in central Northern Nigeria. *African Journal of Biotechnology*, 7 (25): 4758-4764.
- Saldaña, J. (2009). The coding manual for qualitative researchers. Sage Publications, Ltd., London.
- Sambo, A.S. (2005). Renewable Energy for Rural Development: The Nigerian Perspective. *ISESCO, science and technology vision*. 1 : 12 – 22.
- Sambo, A.S. (2008 a). Renewable Energy Options for the Environment and Sustainable Development in Nigeria. Paper Presented At The National Workshop On Energy Investment And Private Sector And Participation At The Petroleum Training Institute, Warri.
- Sambo, A.S. (2008 b). Matching Electricity Supply with Demand in Nigeria. *International Association for Energy Economics. Fourth Quarter*, 32:36. www.iaee.org/en/publications/newsletterdl.aspx?id=56 - accessed 25/06/2011.
- Sambo, A.S. (2009). The Challenges of Sustainable Energy Development in Nigeria. *Paper Presented at the "Nigerian Society of Engineers Forum", 2nd April, 2009 at Shehu Yar'Adua Centre, Abuja.*
- San, V., Spoann, V., Ly, D. & Chheng, N. C. (2012). Fuelwood consumption patterns in Chumriey Mountain, Kampong Chhnang Province, Cambodia. *Energy*, 44: 335 -346.
- Sango S. (2011). Kerosene scarcity: Unending Woes for the poor. Vol.25: No.61402. *Vanguard Newspaper*, 25th July, 2011 edition.
- Shackleton, C.M.; McConnachie, M.; Chauke, M.I.; Mentz, J.; Sutherland, F.; Gambiza, J., & Jones, R. (2006). Urban fuelwood demand and markets in a small town in South Africa: Livelihood vulnerability and alien plant control. *International Journal of Sustainable Development and World Ecology*, 13(6): 481-491.

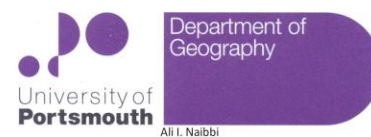
- Scott, A. (2012). The energy trilemma for developing countries, ODI development progress blog. <http://www.developmentprogress.org/blog/2012/08/03/energy-trilemma-developing-countries> - accessed 11/02/2013.
- Shalaby, A. & Tateishi, R. (2007). Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. *Applied Geography*, 27:28-41.
- Schulte-Bisping, H., Bredemeier, M. & Beese, F. (1999). Global availability of wood and energy supply from fuelwood and charcoal. *Ambio*, 28 (7): 592-594.
- Schweik, C. M. & Thomas, C. W. (2002). Using Remote Sensing to Evaluate Environmental Institutional Designs: A Habitat Conservation Planning Example. *Social Science Quarterly*, 83 (1): 244-264.
- Sleight, P. (1993). Targeting customers: How to use geodemographic and lifestyle data in your business. NTC Publications limited Henley-on-Thames, UK.
- Sodeji, B. (2013). Nigeria: The Potiskum Question. Daily Trust News Paper, 31/03/ 2013 Edition. <http://allafrica.com/stories/201304010601.html> - accessed 30/09/2013
- Sovacool, B.K. (2011). Security of energy services and uses within urban households. *Current Opinion in Environmental Sustainability*, 3:218– 224
- Sweet Crude, (2011 a). Fuel subsidy gulps 1.3 trillion Naira in 2010. *A Monthly Review of the Nigerian Energy Industry*. Vol.02: No.27. *Vanguard Newspaper*, July, 2011 edition.
- Sweet Crude, (2011 b). Electricity Tariff goes up 18%- NERC warns operators on service delivery. *A Monthly Review of the Nigerian Energy Industry*. Vol.02: No.27. *Vanguard Newspaper*, July, 2011 edition
- Sweet crude Newspaper, (2012). Niger Floats oil firms “to tap potentials of Bida basin” - *A monthly review of the Nigerian energy industry* . *Vanguard Newspaper*, 25th -10, 2012 edition. <http://sweetcrudereports.com/2012/10/25/niger-floats-oil-firms-to-tap-potentials-of-bida-basin/> -, Accessed 3rd November, 2012.
- Tao, M. (2010). Using cartograms in disease mapping. Unpublished Doctoral Thesis, University of Sheffield, Sheffield.
- This Day Newspaper (2012). Cost, Gains of Fuel Subsidy Removal. *This Day Newspaper*, 18/01/2012 edition.
- Tobler, W. (1973). Choropleth maps without class intervals? *Geographical Analysis*, 5:262-265.
- Thomas, G. S. (2012). What the difference is between households and families. American City Business Journals. <http://www.bizjournals.com/bizjournals/on-numbers/scott-thomas/2012/09/drawing-the-distinction-between.html> - accessed 19/08/2013
- Tsai, P.J. (2011). The analysis of geographically weighted regression pertaining to gastric cancer and Taiwanese ethnic communities. *International conference on Environmental, Biomedical and Biotechnology*, IPCBEE Vol.16. IACSIT press, Singapore.
- Tsan, A. & Odemwingie, E. (2013). Ministries, CBN Boycott House SURE- P Probe. *Leadership Newspaper*, 23/01/2013 edition.

- Tso, B. & Mather, P.M. (2009). Classification Methods for Remotely Sensed Data. 2nd edition. Boca Raton, FL: Taylor and Francis.
- Tole, L. (2002). An estimation of forest cover and change in Jamaica using Landsat MSS data. *International Journal of Remote Sensing*, 23, (1): 91-106.
- Transparency International, (2012). Corruption by country / territory. <http://www.transparency.org/country#NGA> accessed- 10/12/2012.
- Troncoso, K., Castillo, A., Masera, O. & Merino, L. (2007). Social perceptions about a technological innovation for fuelwood cooking: Case study in rural Mexico. *Energy Policy* 35 (2007): 2799 – 2810.
- Ukaejiofo, A. N. (2009). Identifying Appropriate Tools for Land Governance in Nigeria. Paper presented at the 7th FIG Regional Conference; Spatial Data Serving People: Land Governance and the Environment – Building the Capacity. Hanoi, Vietnam, 19-22 October, 2009 TS 1B – Land Governance and Land Management 15/15.
- United Nations (UN), (2012). General assembly A/67/257 accelerating progress towards the millennium development goals: Options for sustained and inclusive growth and issues for advancing the United Nations development agenda beyond 2015. Annual Report to the Secretary General, United Nations, New York.
- United Nations Development Programme (UNDP), (2005). Energizing the millennium development goals- a guide to energy's role in reducing poverty. Bureau for Development Policy Energy and Environment Group. New York. www.undp.org/energyandenvironment - accessed 10/ 01/ 2011.
- United Nations Development Programme (UNDP) , (2009). Human Development Report, Nigeria 2008 – 2009: Achieving growth with equity. Published for the United Nations Development Programme (UNDP), Nigeria.
- United Nations Development Programme (UNDP), (2010). Human Development Report: The real wealth of nations: pathways to human development. New York: Palgrave Macmillan for the United Nations Development Programme, p.162-191.
- U.S. Geological Surveys (USGS), (2006). Landsat: A global land-observing program fact sheet , 023-03. <http://egsc.usgs.gov/isb/pubs/factsheets/fs02303.html> - accessed 11/ 01/ 2011.
- U.S .Geological Survey (USGS), (2010). USGS Global Visualization Viewer. <http://glovis.usgs.gov/> - accessed 20/ 02/ 2012.
- Van Der Molen, P. (2006). Tenure and tools, two aspects of innovative land administration. Background paper 'evening lecture' RICS .London. http://www.fig.net/council/molen_papers/rics_12_2006.pdf- accessed 5/1/2011.
- Webb, E. L. & Dhakal, A. (2011). Patterns and drivers of fuelwood collection and tree planting in a Middle Hill watershed of Nepal. *Biomass and Bioenergy*, 35: 121-132.
- Williams, J. P. (1983). The social organisation of fuel wood procurement and use in Africa: A study of the division of labour by sex. Unpublished Doctoral Thesis, University of Washington, USA.
- Winchester, H.P.M. (1999). Interviews and questionnaires as a mixed methods in population geography: The case of lone fathers in Newcastle, Australia. *The Professional Geographer*, 51(1): 60-67.

- World Resources Institute (WRI), (2007).
http://earthtrends.wri.org/maps_spatial/maps_detail_static.php?map_select=219&theme=6 - accessed 19/01/2010.
- Wright, S.J. & Muller-Landau, H. C., (2006). The future of tropical forest species. *Biotropica*, 38 (3): 287–301.
- Wunder, S. & Verbist, B. (2003). The impact of trade and macroeconomic policies on frontier deforestation. Bogor, Indonesia, World Agroforestry Centre ICRAF .
- Xavier, S. & Subramanian, A. (2003). Addressing the natural resources curse: an illustration from Nigeria IMF Working paper 9804. National Bureau of Economic Research.
- Yakubu, R. & Abbass, I. M. (2012). National Poverty Eradication Programme (NAPEP) and poverty alleviation in rural Nigeria: a case study of Giwa local government area of Kaduna state. *European Scientific Journal*, 8 (18): 1857–7881.
- Zein-Elabdin, E.O. (1997). Improved stoves in Sub-Saharan Africa: The case of the Sudan. *Energy Economics*, 19: 465- 475.

Appendices

Appendix 1: Household Questionnaire

**A. Facts about the household (family profile)**

1. How many people are there in this household?

2. Are you or any member of this household employed? Yes ☐ No ☐
If the answer to 2 is Yes move to question 3; otherwise go to question 5

3. What type of job do you or any member of the household do?
Please specify whether full-time or part-time?

Civil servant ☐ Farming ☐ Others ☐

4. What is the average monthly income of this household?

< 18,000 Naira ☐ 18,000-30,000 Naira ☐ > 30,000 Naira ☐

B. Questions about family use of Fuelwood (Traditional cooking fuel)

5. Do you use Fuelwood? Yes ☐ No ☐

If the answer to 5 is Yes move to question 6; otherwise go to question 12

6. Do you buy the fuelwood?

Yes always ☐ Yes sometimes ☐ Never (Self procurement) ☐

If the answer to 6 is Yes move to question 7; if Never go to question 9

7. How much do you spend on the purchase of fuelwood in a typical week?
(In Nigerian Naira)

50-99 ☐ 100-199 ☐ 200- 399 ☐ 500 and above ☐

Please specify amount if more than 500

8. Is there any difference in the money that you spend on fuelwood in terms of seasonal variation?

For example do you spend more in the months of December or January (Harmattan season) compared to July or August (Rainy season)?

Please specify

9. How far away is the wood procured from your house?

Please specify time in terms of walking distance

10. What species of wood do you prefer to use as Fuelwood?

Please specify

- a)
- b)
- c)
- d)

11. Do you get your preferred wood species easily?

Yes

☐

No

☐

If No, Please specify why?

12. Do you use Charcoal for cooking?

Yes

☐

No

☐

If the answer to 12 is Yes, move to question 13; otherwise go to question 14.

13. Do you usually buy it or do you make it yourself?

Buying

☐

Self making

☐

14. Is there any time of the year you use more fuelwood than normal?

Cool dry season (Harmattan)

☐

Hot dry season

☐

Rainy season

☐

Indifferent

☐

15. How much (quantity) fuelwood on average does your household use per week?

Please specify in bundles (*Dami*)

16. How much charcoal on average does your household use per week?

Please specify in Kg or price in Naira

C. Questions about family use of Fossil fuel (Modern cooking fuel)

17. Do you use any other source of energy for your cooking or heating?

Yes

☐

No

☐

If the answer to 17 is Yes, move to 18, otherwise go to 19

18. Can you list the other sources?

For example: Electricity ☐ kerosene ☐ gas ☐ coal ☐

Others please specify

19. Is there any obstacle that stops you from switching to the use of other forms of energy such as electricity, kerosene or gas? Yes ☐ No ☐

Please explain

20. Would you be willing to use other alternatives to fuelwood? Yes ☐ No ☐

D. Questions about environmental awareness (Deforestation)

21. Have you noticed any changes in the vegetation pattern around this area compared to the past?

Yes ☐ No ☐

If Yes, please provide observations using the details below, if No go to question 23

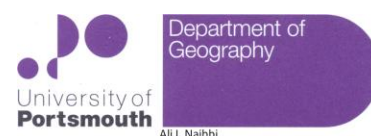
More trees now	<input type="checkbox"/>	Less trees now	<input type="checkbox"/>	More shrubs now	<input type="checkbox"/>
Less shrubs now	<input type="checkbox"/>	More grasses now	<input type="checkbox"/>	Less grasses now	<input type="checkbox"/>
Indifferent	<input type="checkbox"/>				

22. What do you think are the causes of these changes?

23. What measures do you think can be taken to combat these changes?

Thank you very much for your cooperation and time

Appendix 2: Questionnaire for commercial fuelwood vendors

**A. Facts about fuelwood business profile**

1. Is this the only business you do to support yourself and your family?

Yes

☐

No

☐

If No please specify others

2. Why are you in this business?

For example because of profit or there is no other job available.

Please specify

3. How many people are working under you or are in your group?

4. What is their role in terms of labour division? For example the nature of their various jobs.

Please specify

5. What is the structural system (business distribution chain) of commercial fuelwood?

Please specify

6. How is the business in terms of profit? For example whether the business is profitable or otherwise.

Please specify

7. What do you consider to be the primary purpose of wood harvest?

8. Is there any tax you pay to the government as part of this business?

If Yes specify how much you pay per month please

9. Do you sell charcoal?

Yes

☐

No

☐

If the answer to 9 is Yes move to 10; otherwise go to 11.

10. Where is the source of the wood to make the charcoal?

Please specify area and approximate distance if possible

B. Facts about Fuelwood Procurement Process and Pricing

11. What sort of transportation system do you use in conveying the wood?

12. How far away do you get the fuelwood supply from?

Please specify (areas and distance if possible)

13. What tools do you use in splitting the trees?

14. How is the price of fuelwood being determined?

For example, whether there is any standard measurement use in determining the price of fuelwood.

15. How is the activity of fuelwood organised in a typical year in terms of seasonal variation?

For example, whether the differences in seasons (Harmattan season, rainy season or hot dry season), affect fuelwood procurement task.

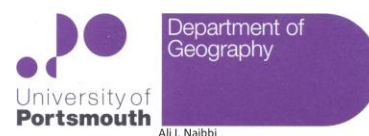
16. How is the activity of fuelwood distributed in a typical year in terms of selling?

For example, whether the differences in seasons (Harmattan season, rainy season or hot dry season), affect fuelwood pricing.

17. Is there any suggestion you can offer to improve the industry of fuelwood?

Thank you very much for your cooperation and time

Appendix 3: Introductory Note and Consent Agreement

**Participant Information Sheet**

I am a PhD student from the University of Portsmouth, United Kingdom. I am conducting research on the “deforestation impact of fuelwood consumption in Northern Nigeria” and I am currently conducting a survey as part of this work. I would like to use some of your time (10-15 minutes) to help me answer some questions relating to this research. I need some information about you to help me find out the situation of fuelwood in this area. The information given will be used only for research purposes. You may refuse to answer any question you don’t want to and even quit the interview at any point.

I would like to reiterate that all responses will remain anonymous but the summaries of the results will be available in the public domain via my final PhD report.

Thank You.

Participant certification: Please tick as appropriate

	Please tick	
1. I confirm that I understand the information sheet for the study described in the participant information sheet, and that I have had the opportunity to ask questions.		
2. I understand that my participation is voluntary and that I am free to pull out from the study at any time, and I do not have to give a reason for this.		
3. I agree to take part in the study described in the participants’ information sheet.		
<i>Include/delete as appropriate</i>	Please delete	
	Yes	No
4. I agree to the interview/focus group/consultation being audio recorded.		
5. I agree to the use of an anonymous quotes in written work or reports based upon this project		

 Name of Participant

Date

Signature

 Name of Researcher

Date

Signature

Appendix 4: Land tenure system in Nigeria

Land consists of the earth surface, the materials beneath the surface, the air above the surface, and everything attached to the surface (Van Der Molen, 2006 p.2). In other words, it should be perceived as more than just the 'land'. In this sense therefore, land can be described as a universal factor of production around which life revolves (Otubu, 2008 & Ukaejiofo, 2009). Although the concept of land ownership as it existed in the pre-colonial African societies has been affected considerably by colonial rule which Obioha (2008) interpreted as a drift from the overwhelming religious, social and traditional values attached to land to economic values. For example, before the colonisation of Nigeria, the country had an unwritten traditional and customary law in which land was either owned by individuals or by the family or the community under the authorities of Chiefs and Emirs (Ukaejiofo, 2009). This change in the perception of land triggered the lust and quest for acquiring more land for economic benefits. It is obvious that the interplay between land and economic prosperity has promoted the formulation of the constitutional provision of private land property rights in Africa (Otubu, 2008).

The colonial era brought some changes in the way land tenure was dealt with in most parts of Africa which are of course associated with some discrepancies (Ukaejiofo, 2009). In Nigeria for example, the colonial administrators tried to formulate a land tenure system that would integrate all the differences perceived in the past, which ended up in producing three different land tenure systems in the country based on the division of the colonies (Ukaejiofo, 2009). After independence in 1960, the government changed the tenure system of land in the country in March 1978 by adopting a new policy that addressed the discrepancies inherited from the colonial administrators. Some of the reasons that promoted the need for adopting the new system are the difficulties faced by the Government and private institutions in acquiring land for development (Ako, 2009 p. 294). The new land tenure policy called '1978 LAND USE ACT'(Nigerian Constitution, 1990; Adedipe et al., 1998; Obioha, 2008; Otubu, 2008 & Ako, 2009) dictates that all land and its resources (vegetation resources inclusive) in the country belong to the government (FG, SG and LGAs). And individuals can only own land from the government through a lease, which is limited to a period of 99 years only (subject to renewal). The new land policy also defined the rights of an individual, group or organisations to own a property, transfer and abolishment of property rights and the registration process.

It is important to state here that even with the introduction of the 1978 Land Use Act, there are still complexities in the Nigerian land tenure system that can be illustrated by the social conflicts in the country emanating from the desire to control or possess land resources for economic benefits. There are still crises in the country today (although not the focus of this study discussion, but worth mentioning) as a result of land resource control. See Ako (2009) for more details of the existing conflicts in the Niger Delta area in the Southern Nigeria over land resource control. Other land control conflicts include the ongoing conflicts in Jos between the indigenous and the migrants (Porter et al., 2003), the Tiv and Jukun crises in Taraba state all in the Northern part of Nigeria.

Appendix 5: Some of the Nigerian legislations on the environment that affects vegetation

The role of legislation in inducing responsible attitudes and behaviours towards the environment cannot be overlooked. Legislation serves as an effective instrument for environmental protection, planning, pollution, prevention and control. The following provides a summary of some Nigerian legislation on the environment that affects vegetation.

- **THE CONSTITUTION OF THE FEDERAL REPUBLIC OF NIGERIA (1999)**

The constitution, as the national legal order, recognizes the importance of improving and protecting the environment and makes provision for it. Relevant sections are:

- **Section 20** makes it an objective of the Nigerian State to improve and protect the air, land, water, forest and wildlife of Nigeria.
- **Section 12** establishes, though impliedly, that international treaties (including environmental treaties) ratified by the National Assembly should be implemented as law in Nigeria.
- **Section 33 and 34** which guarantee fundamental human rights to life and human dignity respectively, have also being argued to be linked to the need for a healthy and safe environment to give these rights effect.

- **NATIONAL ENVIRONMENTAL STANDARDS AND REGULATIONS ENFORCEMENT AGENCY (NESREA) ACT 2007**

Administered by the Federal Ministry of Environment, NESREA Act of 2007 replaced the Federal Environmental Protection Agency (FEPA) Act. It is the embodiment of laws and regulations focused on the protection and sustainable development of the environment and its natural resources. The following sections are worth noting:-

- **Section 7** provides authority to ensure compliance with environmental laws, local and international, on environmental sanitation and pollution prevention and control through monitory and regulatory measures.

- **ENVIRONMENTAL IMPACT ASSESSMENT ACT OF 1992**

The purpose of the EIA Act is to among other things establish before a decision taken by any person, authority corporate body or unincorporated body including the Government of the Federation, State or Local Government intending to undertake or authorise the undertaking of any activity that may likely or to a significant extent affect the environment.

- **LAND USE ACT (CAP 202, LFN 2004)**

The Land Use Act places the ownership, management and control of land in each state of the federation in the Governor. Land is therefore allocated with his authority for commercial, agricultural and other purposes

- **THE NIGERIAN URBAN AND REGIONAL PLANNING ACT (CAP N138, LFN 2004)**

The Urban and Regional Planning Act is aimed at overseeing a realistic, purposeful planning of the country to avoid overcrowding and poor environmental conditions. In this regard, the following sections become instructive:-

- **Section 39 (7)** establishes that an application for land development would be rejected if such development would harm the environment or constitute a nuisance to the community.
- **Section 72** provides for the preservation and planting of trees for environmental conservation.

- **THE FEDERAL NATIONAL PARKS ACT, CAP N65, LFN 2004.**

The National Parks Act is concerned with the establishment of protected areas used for resource conservation, water catchments protection, wildlife conservation and maintenance of the national eco-system balance.

OTHER REGULATIONS AT STATE LEVEL (STUDY AREA)

- Yobe State Ministry of Environment, Damaturu
- Yobe State Environmental Protection Agency, Damaturu

Source: Environmental Law Research Institute (ELRI) (2011).

Appendix 6: Graphic outputs of the Remote Sensing Image processing stages

